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ABSTRACT

These hearings focused on the role that the National Science Foundation (NSF) should play in a national effort to improve mathematics and science (M/S) education in elementary and secondary schools. The impact of past NSF activities, current crisis in M/S education, role of organizations in M/S education, government role, federal legislation, and minority group participation were among the areas addressed by individuals presenting testimony. These included: Edward A. Knapp (NSF director), George A. Keyworth II (science advisor to President Reagan), Senator Daniel K. Inouye, classroom teachers/department heads (John O. Thayer, Karen J. Howell, Patricia Pantano Nussbaum, Louis Goffredi, Iona Brown, and Clinton Brown), Joseph C. Hogan (representing the National Society of Professional Engineers and the National Society for Engineering Education), Robert W. Parry (representing the American Chemical Society), Robert F. Boehm (representing the American Society of Mechanical Engineers), Franklin Flint (representing the American Institute of Biological Sciences), and Holly Knox, director of the Project on Equal Education Rights. Also included is additional testimony from the Association of American Publishers Business and the Business and Professional Women's Clubs, Inc. and (in an appendix) an outline of the Administration's proposed activities to be implemented by NSF in M/S education. (JN)

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REVIEW OF MATHEMATICS AND SCIENCE EDUCATION PROGRAMS, 1983

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HEARING

BEFORE THE

COMMITTEE ON LABOR AND HUMAN RESOURCES UNITED STATES SENATE

NINETY-EIGHTH CONGRESS

FIRST SESSION

ON

TO REVIEW MATHEMATICS AND SCIENCE EDUCATION IN PRIMARY AND SECONDARY SCHOOLS, FOCUSING ON THE ROLE THAT THE NATIONAL SCIENCE FOUNDATION SHOULD PLAY IN A NATIONAL EFFORT TO IMPROVE THESE EDUCATION PROGRAMS

APRIL 18, 1983

Printed for the use of the Committee on Labor and Human Resources

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REVIEW OF MATHEMATICS AND SCIENCE EDUCATION PROGRAMS, 1983

MONDAY, APRIL 18, 1983

U. S. Senate,
Committee on Labor and Human Resources,
Washington, D.C.

The committee met, pursuant to notice, at 10:36 a.m., in room SD-106, Dirksen Senate Office Building, Senator Orrin G. Hatch (chairman of the committee) presiding.

Present: Senator Hatch.

OPENING STATEMENT OF SENATE HATCH

The Chairman. This morning's hearing is devoted to a consideration of the role that the National Science Foundation should play in a national effort to improve mathematics and science education in our primary and secondary schools. The NSF is the premier champion within the Federal Government of mathematics and science, and it is both important and proper that the NSF help our Nation's teachers in their work, for these teachers face a very huge task.

We live in an age of technology and science. Technology and science have filled our world with wonders that would have been astounding to people just a few generations ago. With these wonders has come a whole host of challenges. Work has changed, lifestyles have changed. We must concern ourselves as never before with pollution and the environment, and questions regarding the quality of life.

Increasingly, a knowledge of technology and science is needed to perform the jobs that our modern economy requires. Increasingly, a wise consideration of public policy requires an understanding of science. If America is to retain its economic preeminence in the world, and if Americans are to understand this world, Americans must have a basic understanding of mathematics and science.

Yet, while the importance of math and science has grown, math and science education has been woefully neglected in our primary and secondary schools. Too few resources have been devoted to the task. Too little support has been given to our teachers.

These problems are pervasive and we must all assume some responsibility for resolving them. Education in this country has traditionally been the responsibility of parents, communities, and the States, and here is where the primary responsibility must remain, in my opinion. Parents, communities and States must bear the greatest burden in the necessary effort to improve math and science education. The education of individual children cannot be puppeteered from Washington.

But, having said this, I freely acknowledge that the Federal Government bears a responsibility to assist parents, communities, and States. It is the responsibility of the Congress to adjust national priorities to meet new circumstances. We are meet here this morning to consider just such a revision of priorities. The problem of math and science education has grown to a point where Federal assistance is required. Federal resources must be shifted to meet this need. This means that we in the Congress must bear the heat from other interests for projects that must be cut back to provide the necessary resources, but that is our job and we will just have to meet this responsibility.

The Federal money we can devote to our end may be large in absolute terms; but it cannot be large relative to the needs of 16,000 school districts and millions of school-age children. Thus, if Federal money is to make a real contribution, it must be carefully targeted. I would like to see an emphasis on assisting the teachers who must bear the burden of educating our young. Specifically, funds should be devoted to courses and programs that will enable teachers to improve their skills, and to the development of teaching materials that will enhance classroom effectiveness.

The Labor and Human Resources Committee is working on legislation that will contain programs for both the Department of Education and the National Science Foundation. The emphasis that I have suggested should be met through the combined efforts of both the department and the foundation. One of the essential considerations this morning will be which functions would be best directed by the foundation.

This question and others will be addressed by Dr. Keyworth and Dr. Knapp, who are representing the administration. They will be followed by a panel of working teachers who will give us the view from the front—something that is frequently needed in the Congress. I welcome their fresh assessment of the situation. Also, we shall hear from a panel representing professional scientists. The committee will be interested to hear what they and their members can do to assist teachers. I understand that several professional societies are already operating cooperative programs. This should be an interesting hearing.

We Americans must do more than cope with the future. We must adapt it to humane ends. For this, we need the foresight to impart to our children a fuller grasp of the collective knowledge of our society, because there is no better preparation for the future than the proper education of our youth.

At this time, we will introduce Dr. George Keyworth, who is the Presidential Science Adviser. Dr. Edward A. Knapp, Director of the National Science Foundation and Dr. Schmitt. This first panel has come to represent the administration's views on the role that the National Science Foundation should play in a new Federal initiative to improve mathematics and science education.

Dr. George Keyworth is the Presidential Science Adviser and, of course, Dr. Knapp is Director of the National Science Foundation.

I want to thank you publicly, Dr. Keyworth, for helping us with some very crucial bills—scientific bills—in the last Congress. I think you're doing a terrific job down at the White House. We're very much interested in what all three of you have to say here today.

STATEMENT OF DR. GEORGE A. KEYWORTH II, SCIENCE ADVISER TO THE PRESIDENT, AND DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT

Dr. KEYWORTH. Thank you very much, Senator Hatch.

The Nation's need to improve the quality of education in the sciences and mathematics—from kindergarten through the universities—is well established. Moreover, we anticipate growing quantitative demands for scientifically and technically trained people—from technicians to Ph. D.'s—as American industry confronts the growing challenge of industrial competition from foreign countries.

But what frustrates all of us is that we've seen the quality of education programs and the achievement of our students decline during a period of great national advances in science and technology, and during a time of substantial public investment in education. Consequently, we now find ourselves in a quandary. What must we do—what can we do—to prepare our children to live and work in the demanding times we face?

We frequently hear the 1960's extolled as a golden age for science and math education; many people would like to replicate what we did then. Indeed, the national sense of crisis following Sputnik, combined with the mobilization of the science community to improve education, did have a remarkable effect. But as happens with most things that are crisis-driven, we overreacted in the short term and failed to develop the steady growth and improvement that would have served the Nation better.

In fact, the enthusiasm for science soon faded as the United States quickly responded to the supposed crisis and demonstrated our technological superiority through the Apollo program. By the time U.S. astronauts stepped onto the Moon in 1969, the Nation had lost much of that impetus for rigorous education in science and math.

In the early 1970's, education encountered further setbacks. This was partly as a result of the dashed expectations of the many eager new teachers and engineers who, encouraged during that crisis atmosphere, then found a discouraging lack of demand for their services. Their disappointment was transmitted back to the student population, and we embarked on a cycle of first too many, then too few students in science and engineering.

The real question we face today is how the nation will develop or regain a realistic commitment to science and math training, as well as to high standards in education across the board. I would argue that the central question is not so much how to pay for education, but how to motivate students to want and demand something better.

It is clear to me that the most lasting commitment, the one we can build a solid future on, must emanate from the broadest possible base—beginning with the family and then extending to the schools, to the science and industrial communities, to local and

State governments, and to the Federal Government. I have little confidence, especially in light of our experience during the 1970's, that Federal activity alone can significantly improve the Nation's success in science and math education.

I think many people share that attitude today and are beginning to take a greater personal interest in what they can do to raise standards and improve resources at the local and State levels. We shouldn't underestimate the importance and long-term impacts of recent university and high school decisions to raise educational standards—a marked contrast to the past decade when they allowed those same standards to slip. And we're seeing increasing local and State government actions to address shortages of math and science teachers, as well as industrial efforts to aid instructional programs in their communities. Today, we're seeing a developing recognition that education is everyone's responsibility.

Senator Hatch, because of these changing attitudes, I feel much more confident in the climate of 1983 than I did in 1981 that the Federal Government, in partnership with these other sectors, can play an effective role in long-term science and math education improvement.

However, we must remember that we're talking about an immense activity; this Nation spends more than $110 billion annually on precollege education. Given the limited Federal resources available, it's obvious that our priority is to identify activities that can best be carried out by the Federal Government and whose results will be highly multiplied in practice. For that reason the precollege programs proposed by the President all aim to improve the supply and effectiveness of science and math teachers. After all, for every teacher affected by these programs, as many as 150 students can benefit every year.

We have proposed to allocate responsibilities for these new programs between the National Science Foundation and the Department of Education. These two agencies, both with extensive experience in developing and implementing education programs, bring two quite different, but complementary, skills to this mission. The Department of Education will concentrate on the actual training of new science and math teachers. NSF will focus on research and development of better materials and techniques—which incorporate new technologies and new research about how people learn most effectively—in order to improve the ability of teachers to teach. NSF will also conduct a long-overdue program to honor and reward current teachers who have done outstanding work. The Department of Education's activities, to be carried out through block grants to the States, will provide scholarships for people already holding college degrees to enable them to take additional coursework and qualify them to teach science or mathematics.

Senator Hatch, the administration believes it has proposed an affordable series of programs to address its responsibilities in precollege science and mathematics education. Dr. Knapp can describe the NSF's proposed programs in greater detail, and we would both be pleased to respond to questions from the committee.

Senator HATCH. Thank you, Dr. Keyworth.

Dr. Knapp, we'll turn to you. We're also happy to have Dr. Roland Schmitt, who's a member of the National Science Foundation Board, and who, as I recall, is a vice president of General Electric Corp.

Let's turn it over to you, Dr. Knapp.

STATEMENT OF DR. EDWARD A. KNAPP, DIRECTOR, NATIONAL SCIENCE FOUNDATION, ACCOMPANIED BY ROLAND W. SCHMITT, SENIOR VICE PRESIDENT FOR CORPORATE RESEARCH AND DEVELOPMENT, GENERAL ELECTRIC CO., AND MEMBER OF THE NATIONAL SCIENCE BOARD

Dr. **Knapp**. Thank you, Senator Hatch.

I'm pleased to be here today for your hearings on the administration's fiscal 1984 budget request for the Foundation. Let me introduce Roland W. Schmitt, senior vice president for corporate research and development, General Electric Co., and member of the National Science Board. We would both be pleased to answer any questions you may have following my prepared remarks

Today's hearings focus on science and engineering education and training, a subject of great current interest and concern in the Nation, the Congress, and the administration. We at the Foundation share this concern, and are moving in a concerted and deliberate way to develop a clear consensus on the nature of this problem and the strategies needed for its alleviation.

The educational base for producing the Nation's future research scientists, engineers, and technicians consists of a continuum extending from primary and secondary schools through undergraduate colleges and universities to graduate and professional schools and on to the post-doctoral appointment. As students move through these institutions, they make choices which are influenced very much by the quality of the faculty and teaching which they encounter and, at later stages, by the opportunities they have to gain first hand knowledge of the research process. In a real sense, it can be argued that the entire budget of the Foundation serves to promote and strengthen science and engineering education.

NSF's major scientific education responsibilities lie in graduate education and training in research which it supports through fellowships, stipends in research awards for graduate research assistants, and post-doctorate awards. The training of graduate students through an apprenticeship system of working with university faculty, who are themselves successful researchers, is an absolutely critical part of this enterprise. NSF also has a role, but necessarily a more selective one, in the area of precollege education.

Precollege education in the United States is a vast, decentralized enterprise with some 16,500 local school districts. Since the beginning of the Republic, it has been—and remains—a major responsibility of States and localities reflecting the deeply held belief that education should be responsive to the needs and views of the local community.

There has also been considerable degree of Federal interest in precollege education since our first days as a republic, because of the belief that a well-educated citizenry is the backbone of a democracy. To that concern we would add, today, the belief that a competitive, strong economy and secure society depend on the quality of scientists, engineers, and technically trained personnel. It is also true, however, that there has not been a consensus on the appropriate Federal role in precollege education, including precollege education in science and mathematics.

It was for this reason that the National Science Board established a Commission on Precollege Education in Mathematics, Science, and Technology in April 1982 The Commission has been carrying out its work by articulation of the causes of, and problems with, the state of precollege training in science and mathematics today. I anticipate that the Commission will complete its work early this fall, somewhat ahead of schedule. I anticipate that many of their recommendations will be considered in formulating the NSF budget request for 1985.

NSF will always have a limited, but critically important, role in precollege education within its basic charter and overall responsibility for the health of science. In fulfilling these responsibilities, it is incumbent upon the Foundation to select and design its activities in such a way as to: exert high leverage, demonstrate leadership in the national interest through example setting and prototype testing, involve research scientists and engineers in educational concerns, be as flexible as possible and receptive to new ideas; and to promote the involvement of State and local governments, and the private sector, in its undertakings.

As you are aware, the 1983 HUD-independent agencies appropriations conference report required the NSF to develop a program plan for a $15 million activity at the precollege level. This proposed plan has two major components: first, in materials development. The NSF will support the development of exemplary materials and models for the continuing improvement of teachers. The principal products of this component will be better, more effective approaches to teacher training and better tools for teachers and students to use in their classrooms and laboratories.

Second, a program in teacher incentives. The teacher-incentive activities will focus on the unique problem of motivating, recognizing, and bringing up to date science and mathematics teachers who are among the best the profession has to offer. This includes two programs—the Presidential Awards for Science and Mathematics Teaching Excellence, and Teachers Honors Workshops.

This program plan is aimed at raising the level of appreciation of science and mathematics teachers and in improving the teaching of mathematics and science at the precollege level. It has been transmitted to our appropriation committees and is being discussed with their staffs. We anticipate approval very shortly. The 1983 plan will provide the basis for the Foundation's program in 1984.

Mr. Chairman, I believe that a well-educated citizenry is the backbone of a democracy. We are a technological society and this education must lead to a strong basic understanding of science and mathematics among our citizens if they are to make informed decisions about the choices which the Nation faces now and in the future. The Foundation will have a key role in laying the groundwork for this education, as well as providing the framework for the training of our future scientists and engineers.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Knapp follows:]

STATEMENT OF
DR. EDWARD A. KNAPP
DIRECTOR, NATIONAL SCIENCE FOUNDATION

BEFORE THE

COMMITTEE ON LABOR AND HUMAN RESOURCES
U.S. SENATE
APRIL 18, 1983

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE:

I AM PLEASED TO BE HERE TODAY FOR YOUR HEARINGS ON THE ADMINISTRATION'S FY 1984 BUDGET REQUEST FOR THE FOUNDATION. LET ME INTRODUCE ROLAND W. SCHMITT, SENIOR VICE PRESIDENT FOR CORPORATE RESEARCH AND DEVELOPMENT, GENERAL ELECTRIC COMPANY, AND MEMBER OF THE NATIONAL SCIENCE BOARD. WE WOULD BOTH BE PLEASED TO ANSWER ANY QUESTIONS YOU MAY HAVE FOLLOWING MY PREPARED REMARKS.

TODAY'S HEARINGS FOCUS ON SCIENCE AND ENGINEERING EDUCATION AND TRAINING, A SUBJECT OF GREAT CURRENT INTEREST AND CONCERN IN THE NATION, THE CONGRESS, AND THE ADMINISTRATION. WE AT THE FOUNDATION SHARE THIS CONCERN, AND ARE MOVING IN A CONCERTED AND DELIBERATE WAY TO DEVELOP A CLEAR CONSENSUS ON THE NATURE OF THIS PROBLEM AND THE STRATEGIES NEEDED FOR ITS ALLEVIATION.

THE EDUCATIONAL BASE FOR PRODUCING THE NATION'S FUTURE RESEARCH SCIENTISTS, ENGINEERS, AND TECHNICIANS CONSISTS OF A CONTINUUM EXTENDING FROM PRIMARY AND SECONDARY SCHOOLS THROUGH UNDERGRADUATE COLLEGES AND UNIVERSITIES TO GRADUATE AND PROFESSIONAL SCHOOLS AND ON TO THE POST-DOCTORAL APPOINTMENT. AS STUDENTS MOVE THROUGH THESE INSTITUTIONS, THEY MAKE CHOICES WHICH ARE INFLUENCED VERY MUCH BY THE QUALITY OF THE FACULTY AND teaching which they encounter and, at later stages, by the opportunities they have to gain firsthand knowledge of the research process. In a real sense, it can be argued that the entire budget of the Foundation serves to promote and strengthen science and engineering education and science education activities cut across most of the Foundation's programs.

I will describe in some detail how the Foundation's FY 1984 Budget Request addresses this educational base. NSF's major scientific education responsibilities lie in graduate education and training in research which it supports through fellowships, stipends in research awards for graduate research assistants, and post-doctorate awards. This reflects the broad consensus which has developed in this country since the 1950's on the role which the Federal government plays in the support of long-term, fundamental research and in maintaining the health of the basic research enterprise. The training of graduate students through an apprenticeship system of working with university faculty, who are themselves successful researchers, is an absolutely critical part of this enterprise. NSF also has a role, but necessarily a more selective one, in the area of pre-college education.

Pre-College Science and Engineering Education

Pre-college education in the United States is a vast, decentralized enterprise with some 16,500 local school districts. Since the beginning of our Republic, it has been--and remains--a major responsibility of states and localities reflecting the deeply held belief that education should be responsive to the needs and views of the local community.

There has also been a considerable degree of Federal interest in pre-college education since our first days as a Republic because of the belief that a well-educated citizenry is the backbone of a democracy. To that concern we would add, today, the belief that a competitive, strong economy and secure society

DEPEND ON THE QUALITY OF SCIENTISTS, ENGINEERS, AND TECHNICALLY TRAINED PERSONNEL. IT IS ALSO TRUE, HOWEVER, THAT THERE HAS NOT BEEN A CONSENSUS ON THE APPROPRIATE FEDERAL ROLE IN PRE-COLLEGE EDUCATION, INCLUDING PRE-COLLEGE EDUCATION IN SCIENCE AND MATHEMATICS.

AS THE MEMBERS OF THIS COMMITTEE ARE WELL AWARE, THE FOUNDATION HAS OPERATED A BROAD RANGE OF SCIENCE EDUCATION PROGRAMS FOR MANY YEARS. IN THE EARLY YEARS, NSF CONCENTRATED ON SCIENCE CURRICULUM DEVELOPMENT, ON TEACHER TRAINING, AND ON THE DEVELOPMENT OF SCIENTIFIC MANPOWER. THERE WAS GENERAL AGREEMENT AT THAT TIME THAT THIS WAS AN APPROPRIATE ROLE FOR THE FEDERAL GOVERNMENT AND THE FOUNDATION TO PLAY.

THE POTENTIAL FOR OVERLAP BETWEEN THE THEN U.S. OFFICE OF EDUCATION AND THE NSF AT THE PRE-COLLEGE LEVEL WAS RESOLVED BY 'SPLITTING THE FIELD': NSF WOULD FOCUS ON SCIENCE AND MATHEMATICS AND OPERATE MAINLY THROUGH THE SCIENTIFIC COMMUNITY AND THROUGH UNIVERSITIES AND COLLEGES, THE PRIMARY GROUP WITH WHICH IT HAD CONSTANT INTERACTION AND WHICH WAS THE SOURCE OF THE MOST CURRENT SCIENTIFIC KNOWLEDGE. THIS WAS, AFTER ALL, ITS COMPARATIVE ADVANTAGE, GIVEN ITS RESPONSIBILITIES FOR BASIC RESEARCH. THE OFFICE OF EDUCATION, IN TURN, WOULD WORK MAINLY THROUGH STATE AND LOCAL EDUCATION SYSTEMS AND FOCUS ON THE BROAD APPLICATION OF EDUCATION.

THOUGH THE DOLLAR MAGNITUDE OF THE OFFICE OF EDUCATION PROGRAMS--NOT TO MENTION EXPENDITURES BY STATES AND LOCALITIES--FAR OUTSTRIPPED THOSE AVAILABLE TO THE NSF, THERE WAS AGREEMENT THAT NSF'S ACTIVITIES WERE, OVERALL, WELL-TARGETED, WELL-MANAGED AND EFFECTIVE IN MEETING THEIR OBJECTIVES. FOR RELATIVELY SMALL AMOUNTS OF MONEY, WE WERE ABLE TO HAVE A SUBSTANTIAL IMPACT ON PRE-COLLEGE SCIENCE AND MATHEMATICS EDUCATION ACROSS THE NATION.

In the 1970's, however, there was a reorientation of science education programs. Scientific personnel shortages were seen to be less acute and emphasis shifted to broader sets of problems. By 1979, we were administering 28 different programs in science and engineering education with total obligations of $80.0 million. Many were targeted at specific, limited problems and groups. What seemed to be lacking was a clear conception of the nature and needs of science education in the science and engineering enterprise of the country.

It is also clear that the consensus which existed in the 1950's and 1960's on the nature of these needs and on the strategies to be provided had dissolved by the end of the 1970's. Most people agree that there are problems with the state of pre-college training in science and mathematics today.

It was for this reason that the National Science Board established a Commission on Precollege Education in Mathematics, Science and Technology in April 1982. The Commission has been carrying out its work by articulating the causes of, and problems with, the state of pre-college training in science and mathematics today. They have been quite successful in stimulating a broad awareness of the problems and the actions needed to rectify them. A great variety of activities--by professional societies, business leaders, governors, and especially the school systems themselves--is now being generated. I anticipate that the Commission will complete its work early this fall, somewhat ahead of schedule. The Chairman of the National Science Board, Dr. Lewis Branscomb, has assured me that the Board will act quickly on the Commission's recommendations. I anticipate that many of their recommendations will considered in formulating the NSF budget request for FY 1985.

NSF will always have a limited, but critically important, role in pre-college education within its basic charter and overall responsibility for the health of science. In fulfilling these

RESPONSIBILITIES, IT IS INCUMBENT UPON THE FOUNDATION TO SELECT AND DESIGN ITS ACTIVITIES IN SUCH A WAY AS TO: EXERT HIGH LEVERAGE; DEMONSTRATE LEADERSHIP IN THE NATIONAL INTEREST THROUGH EXAMPLE SETTING AND PROTOTYPE TESTING; INVOLVE RESEARCH SCIENTISTS AND ENGINEERS IN EDUCATIONAL CONCERNS; BE AS FLEXIBLE AS POSSIBLE AND RECEPTIVE TO NEW IDEAS; AND TO PROMOTE THE INVOLVEMENT OF STATE AND LOCAL GOVERNMENTS, AND THE PRIVATE SECTOR, IN ITS UNDERTAKINGS.

AS YOU ARE AWARE, THE FY 1983 HUD-INDEPENDENT AGENCIES APPROPRIATIONS CONFERENCE REPORT REQUIRED THE NSF TO DEVELOP A PROGRAM PLAN FOR A $15.0 MILLION ACTIVITY AT THE PRE-COLLEGE LEVEL. THE PLAN HAS BEEN UNDER DISCUSSION FOR SOME TIME WITH OUR CONGRESSIONAL COMMITTEES. THIS PROPOSED PLAN HAS TWO MAJOR COMPONENTS:

- MATERIALS DEVELOPMENT:

  THE NSF WILL SUPPORT THE DEVELOPMENT OF EXEMPLARY MATERIALS AND MODELS FOR THE CONTINUING IMPROVEMENT OF TEACHERS. THE PRINCIPAL PRODUCTS OF THIS COMPONENT WILL BE BETTER, MORE EFFECTIVE APPROACHES TO TEACHER TRAINING AND BETTER TOOLS FOR TEACHERS AND STUDENTS TO USE IN THEIR CLASSROOMS AND LABORATORIES.

- TEACHER INCENTIVES:

  THE TEACHER INCENTIVE ACTIVITIES WILL FOCUS ON THE UNIQUE PROBLEM OF MOTIVATING, RECOGNIZING, AND BRINGING UP TO DATE SCIENCE AND MATHEMATICS TEACHERS WHO ARE AMONG THE BEST THE PROFESSION HAS TO OFFER. THIS INCLUDES TWO PROGRAMS--PRESIDENTIAL AWARDS FOR SCIENCE AND MATHEMATICS TEACHING EXCELLENCE, AND TEACHER HONORS WORKSHOPS.

This proposed program plan would be aimed at raising the level of appreciation of science and mathematics teachers and improving the teaching of mathematics and science at the pre-college level. It would enable the Foundation to exercise relatively high leverage with a limited investment. Also, NSF could utilize its unique relationship with the academic, scientific, and engineering community to foster closer collaboration between it and state, regional, and local school systems in accomplishing this objective. If approved, the FY 1983 plan will be expanded in FY 1984.

The Administration and NSF are anxious to join the Congress in improving the state of pre-college science and mathematics education, but it is essential that a consensus be developed on the approach to be taken. It is also essential that the approach be built on a strong base that is deliberately focused and looks beyond the present to future needs and requirements. This cannot be accomplished overnight.

Undergraduate Colleges

The small, predominantly undergraduate college is another critical part of the educational base which provides the Nation's future engineers and scientists. A significant proportion of those awarded the Ph.D. in science, mathematics, and engineering receive their baccalaureate at these institutions. For the period between 1967 - 1976, for example, more than 9,500 Ph.D. recipients in chemistry had their baccalaureates from 198 predominantly undergraduate colleges. In FY 1982, 20 percent of the NSF Graduate Fellowships went to graduates of such colleges. Since these colleges serve as important pipelines for entry into the system of graduate education, and finally, into the scientific and technical enterprise of the country, it is important that faculty in these institutions receive support and encouragement for maintaining their research capability.

The FY 1984 Budget Request builds on and refocuses earlier NSF research efforts at the undergraduate level by proposing a new program, Undergraduate College Research Support, to be supported at the level of $3.0 million. It will be managed and budgeted for in all of NSF's major research activities to insure that the work it supports is adequately coordinated with other NSF-supported research and facilities at the Nation's leading research institutions.

This new program will emphasize independent research by faculty at predominantly undergraduate colleges, using the physical resources of major university, industrial, or government research centers, and will encourage the inclusion of advanced undergraduate students as part of the research team. Funds for essential, permanent equipment will also be provided. This program will help improve the quality of the research environment at small institutions which serve as major sources of future scientists, engineers, and technicians.

Broadening the Resource Base

The historically Black institutions have played a key role in the education of minorities in this country. Thus it is important that they, as well as other predominantly minority institutions, have strong scientific and engineering research capabilities.

The FY 1984 Budget Request will continue support of the Research Improvement in Minority Institutions program, established in FY 1982 in partial response to Executive Order 12320, to help predominantly minority colleges and universities with graduate science or engineering programs to improve their research capabilities. Some thirty institutions are eligible to compete in this program. Four received awards in FY 1982, and an additional eight awards are anticipated in FY 1983.

The Minority Research Initiation Program provides support for full-time minority faculty who have received no previous Federal research support to establish research programs on their campuses. In FY 1983, 20 awards totalling $2.0 million are planned. This level of support is continued in the FY 1984 request.

In another cooperative effort with this committee to encourage fuller utilization of the Nation's scientific and technical resources, the Foundation established the Visiting Professorships for Women program in FY 1982 with 17 awardees. These visiting professors, in addition to teaching and research, are available to offer advice and provide mentorship at all levels from undergraduate to faculty. Twenty-five awards are planned in FY 1983 at an expenditure of $1.5 million. This level is continued in the FY 1984 request.

Shortages of young faculty in our colleges and universities, particularly in engineering and computer sciences, are of great concern. We have included in our FY 1984 request a Presidential Young Investigator Award program to respond to this growing need. Our plan is to make about 200 awards annually. Each will provide up to five years support, ranging from $25,000 to $62,500 per year per award. This amount will be supplemented by industrial support.

Graduate Research Education

Participation in faculty research projects as a research assistant is the traditional manner through which graduate students gain practical research experience. This apprenticeship system of graduate education is the main reason NSF awards go primarily to researchers at universities and colleges. In the FY 1984 Budget Request, there will be an 8.4 percent increase in the number of graduate students receiving such support under NSF grants, bringing the total to an estimated 10,400. More than

$92 MILLION WILL BE USED FOR THIS PURPOSE, AN INCREASE OF 16.2 PERCENT OVER THE PREVIOUS YEAR.

IN ADDITION TO RESEARCH AWARDS, THE FOUNDATION'S GRADUATE FELLOWSHIP PROGRAM WILL SUPPORT APPROXIMATELY 1,390 GRADUATE FELLOWS IN FY 1984 AT AN INCREASED STIPEND OF $8,100 PER YEAR PLUS A COST-OF-EDUCATION ALLOWANCE OF $4,900. INCLUDED IN THIS TOTAL ARE 45 NEW AND 135 CONTINUING MINORITY GRADUATE FELLOWSHIPS. THESE PRESTIGIOUS AWARDS PROVIDE THREE YEARS OF SUPPORT OVER A FIVE YEAR PERIOD AND ALLOW THE STUDENT TO ATTEND THE GRADUATE PROGRAM OF HIS OR HER CHOICE.

POST-DOCTORAL TRAINING

IN THE TRANSITION FROM STUDENT TO SCIENTIST, THE POST-DOCTORAL EXPERIENCE TRADITIONALLY HAS SERVED TO TOP OFF FORMAL EDUCATION AND IMMERSE THE NEW PH.D. IN FULL-TIME RESEARCH. THIS PROCESS PROVIDES TRAINING TO YOUNG INVESTIGATORS IN VALUABLE RESEARCH SKILLS WHILE OFFERING A SOURCE OF QUALIFIED AND AFFORDABLE RESEARCH ASSOCIATES FOR SENIOR SCIENTISTS.

POSTDOCTORAL OPPORTUNITIES VARY SUBSTANTIALLY FROM FIELD TO FIELD, DEPENDING VERY MUCH ON THE STATE OF THE INDUSTRIAL AND ACADEMIC JOB MARKET. IN THE FOUNDATION'S FY 1984 BUDGET REQUEST, IT IS ESTIMATED THAT NSF AWARDS WILL PROVIDE SUPPORT FOR 3,189 POSTDOCTORAL SCIENTISTS, AT A TOTAL COST OF $54.9 MILLION. THIS IS AN INCREASE OF 8 PERCENT IN THE NUMBER SUPPORTED AND AN INCREASE OF 18 PERCENT IN THE RESOURCES GOING TO THIS IMPORTANT SEGMENT OF THE EDUCATIONAL BASE FOR SCIENCE AND ENGINEERING. PARTICULAR EMPHASIS IS PLACED ON THE EXPANSION OF SUPPORT FOR POSTDOCTORAL POSITIONS IN PLANT BIOLOGY AND MATHEMATICS IN KEEPING WITH THE FOUNDATION'S EMPHASIS ON THESE TWO AREAS IN FY 1984.

CONCLUDING REMARKS

I BELIEVE IT IS IMPORTANT THAT WE KEEP IN MIND THE TOTAL SYSTEM OF EDUCATION AND TRAINING IN THIS COUNTRY FOR PRODUCING OUR FUTURE RESEARCH SCIENTISTS, ENGINEERS, AND TECHNICIANS. THIS SYSTEM CONSISTS OF A CONTINUUM EXTENDING FROM PRIMARY AND SECONDARY SCHOOLS THROUGH GRADUATE SCHOOL AND THE POST-DOCTORATE. I BELIEVE THAT OUR FY 1984 REQUEST ADDRESSES EACH PART OF THIS CONTINUUM.

THANK YOU MR. CHAIRMAN.

Senator HATCH. Thank you, Dr. Knapp. We're very appreciative of these two statements.

I do have a few questions for you. It's generally acknowledged that math and science education in our primary and secondary schools is often inadequate. Indeed this inadequacy is described as a national crisis by some. Whenever the word "crisis" is used, a cry for Federal dollars is sure to follow. Greater Federal spending and regulation is still viewed by many here in the Congress as a panacea for our problems. Keeping this in mind, I would like to ask you to what degree the resolution of this crisis depends on additional Federal funds and Federal direction, and to what degree it depends on the will and diligence of parents and educators in a better utilization of existing resources?

Dr. KEYWORTH. Senator Hatch, let me respond, if I may. I think the very question comes to the very crux of the entire problem today. There is no way that the Federal Government alone is going to be able to lead a restoration of the critical importance of education in general and science and mathematics in particular, as perhaps the most essential investment in our Nation's future. I think there is no question that the Federal Government must be responsive, must assume a leadership role, but the responsibility lies in the hands of the American citizenry, from parents to State and local governments. I think that our programs must be innovative, must respond to this leadership and catalytic role that the Federal Government must play, but it must not be seen in any way as a replacement for the will and incentives that can be provided in the home and the school itself.

Senator HATCH. Thank you. In the last few weeks an impressive number of education interest groups have banded together to advocate a new Federal program that stresses just two functions: a national assessment of math and science education, and the development of programs to enhance the skills of existing math and science teachers. What do you think about this emphasis?

Dr. KEYWORTH. I think there is no question that we are all going to want to draw upon the strongest possible data base and information base that we have. The National Science Foundation, for example, has plans to try to develop the data base that they will need, but let us not delude ourselves. We have a problem on our hands today, the problem is one that is recognized by the majority of the American citizens, and we are responding and we must continue to respond. As assessment by itself, of course, will not solve the problem. I think better and better data base, better and better information that cannot be gained at one time, but will have to be the result of years of work of how to better get knowledge into the classroom, how better to prepare our teachers, how to develop teaching modules that will improve a teacher's capability, all of these are going to have to be the elements in an evolutionary process.

Senator HATCH. Dr. Knapp has testified that there is a materials development component in the plan which will be submitted to the Appropriations Committee. Let me ask a couple of questions about that.

There seems to be some difference of opinion over whether there are not already adequate teaching materials available, and that the issue is really one of helping teachers use the materials more effectively and providing some funds to local and State education agencies to buy such materials. What's your view on this?

Dr. KNAPP. I believe that the need to develop new materials is really quite real. That, in fact, exemplary materials for the teaching of various scientific subjects do need to be updated, do need to be developed at this time for modern presentation of scientific concepts. However, there is a need also to test these materials as they are developed, this is also a part of our plan. I think that the way the National Science Foundation goes about developing these materials through the response to proposals from universities, from colleges, from school districts, from education organizations, the way we go about judging these proposals and then developing the materials on the basis of the quality of the proposal, which have been presented to us, will allow a wide-ranging testing of new ways to present—develop—scientific materials for teachers. We will develop a new and more effective mechanism, perhaps using the new technologies which are available for teaching that have not been available in the past.

Senator HATCH. If NSF develops these types of instructional materials, how do you plan to disseminate them? Do you foresee just making the materials available and allowing the State and local education authorities to choose whatever they desire?

Dr. KNAPP. I think the choice of the materials has to be up to the discretion of the local school districts. I believe that the development of a curriculum out of these materials is a local problem.

Senator HATCH. What sort of collaboration would you require on the development of these materials?

Dr. KNAPP. What kind of—excuse me?

Senator HATCH. Collaboration.

Dr. KNAPP. I would think that the optimum collaboration would be the collaboration between university scientific researchers, representatives from educational institutions of training and education, and the collaboration of the teachers themselves. All of these working together will develop these materials in the best and most cost-effective way.

Senator HATCH. Dr. Keyworth, the committee is seriously considering devoting a portion of the funds available in the math and science legislation to a program that would assist cooperative projects between businesses and schools with Federal matching funds. There has been some concern over which Federal agency should administer such a program, whether it should be the Department of Education or NSF, or maybe even both. Which approach would the Administration prefer?

Dr. KEYWORTH. Senator, it depends on exactly how these resources—these cooperative resources—are to be used. I think we should make clear that the National Science Foundation has strong links in experience with the academic community, universities and colleges in particular. There is a tremendous capability there that should be used in improving our ability to conduct precollege education. The Department of Education, in contrast, has skills and experience in interacting with primarily our precollege educational world. I think it depends on the specific nature. I certainly do share with you, Senator, a strong feeling that we should be very,

very careful to insure that the skills and abilities of each agency are directed toward the appropriate task.

Senator HATCH. Dr. Schmitt, you've been kind enough to come and be with us today. What do you think about a cooperative approach between business and schools to develop better math and science teaching in our public schools?

Dr. SCHMITT. Yes, Senator Hatch. First of all, let me say there is quite a bit of interest in the industrial community in this issue and a recognition of its importance. One of the groups that I'm associated with, the Industrial Research Institute, has had discussions of this issue in its board meetings. So I'm sure the sentiment in the industry generally would be strongly in favor of actions to help solve this problem.

I think the answer to your question would depend on the specific programs. For example, I can imagine that in communities where industry has a presence with scientific and technically based people that forms of cooperation and contribution could be found. However, there are many communities in the United States, as you know, which do not have industry presence of that type. I think cooperation at the local level would be somewhat more difficult in those cases. I think it will have to be a mixture of activities that industry would participate in.

Senator HATCH. Thank you. We appreciate you gentlemen being here today as top science leaders in our administration and the Government. You certainly added a lot to this particular legislative session. We appreciate having your testimony so that we can come up with legislation that will resolve these problems that you've raised here today.

Thank you for coming. I appreciate it.

Panel 2 consists of teachers from public schools in the D.C. area. I'm very happy to have you here with us today. It's very important for the Congress to hear, as Lincoln put it, "from those who have borne the battle."

Mrs. Mitchell, Miss Brown, Ms. Nussbaum, Mr. Brown, Mr. Thayer, Mrs. Howell, and Mr. Goffredi, I welcome you to our hearing this morning on this vitally important issue of math and science education. I understand that we have a number of young people here from your various schools. Can somebody tell me which schools they're from? We're very happy to welcome all of the young people here. What we're talking about is really extremely important to all of our futures in this country. You young people are the future. We're very happy to have you here today. I know these hearings aren't always easy to sit through, but this is one of the most important hearings that we're going to have around here for a long time.

If you folks would let me know what schools the students are from as you testify I would appreciate it.

As you know, we would like to engage you in a discussion about this critical issue and get your firsthand views.

I will just throw out a question here and there, but I want you all to feel free to offer your comments and your opinions as you like. We realize that even though you come together as a panel, that perhaps you do not know each other. We know that your teaching experiences and situations do differ and you may have different views to share. What we really want to know is your perception of current math and science learning and what you would like to do to improve it.

I'm happy to take any statements that any of you would care to make at this time. I might mention that all written statements will be put in the record in full, including the statements of our prior witnesses, as though completely delivered.

Why don't we just start off with whomever you've chosen?

STATEMENT OF JOHN O. THAYER, PHYSICS TEACHER, BALLOU HIGH SCHOOL, WASHINGTON, D.C.

Mr. **Thayer**. There are a few students here from Ballou High School, where I teach.

I prepared a 2-minute statement. I was going to prepare a 4-minute statement but I have a stack of lab reports to grade—my assistant principal said it would take an act of Congress to extend the deadline on that so——

Senator **Hatch**. Well, we always like abbreviated statements, but whatever you care to say.

Mr. **Thayer**. When I was asked whether I would like to participate on this panel I responded positively because I had been thinking for some time about the problems of science and math education.

In particular, I reflect now on the influence of Government-sponsored programs on my own career. It is in fact very unlikely that I would be a classroom teacher today were it not for the training and inspiration offered in several NSF-sponsored summer institutes in which I participated within the period between 1965 and 1972. These institutes addressed curricula in ways which met several needs of science teachers. Knowledge of the subject matter was strengthened, and skills needed to effectively facilitate laboratory experiences were upgraded. Since teachers usually must find summer employment to supplement income, the stipends covering tuition and living expenses were necessary to attract teachers into the programs.

I, personally, would not have attended the institutes without the stipend, in which case I would not have been trained to teach PSSC physics, Harvard project physics or engineering concepts. It must be very frustrating to attempt to accomplish any task which requires training not yet acquired. I have seen physics teachers come and go during the postinstitute period, some of whom might have stayed on had they received up-to-date skills training, encouragement, and inspiration potentially available in a well-designed institute.

I can say with a high degree of certainty that without the institute experiences I would have been taking advantage of other opportunities, for other opportunities were abundant at the time, and continue today for one with skills in physics, electronics, and computers.

The NSF summer institutes have had a lasting effect on my career. I'm not sure what success criteria were used to essentially abolish the institutes, but it seems to me that a program which improves competancies of teachers in critical areas, and influences them to keep on teaching is at least some measure of success.

[The prepared statement of Mr. Thayer follows:]

TESTIMONY TO:

COMMITTEE ON LABOR AND HUMAN RESOURCES OF
THE U.S. SENATE

SUBJECT:

STRENGTHENING SCIENCE AND MATH EDUCATION
---A TEACHER'S VIEW---

SUBMITTED BY:

JOHN O. THAYER, PHYSICS TEACHER
BALLOU HIGH SCHOOL, WASHINGTON., D.C.

APRIL 18, 1983

JOHN O. THAYER

John Thayer was trained as a secondary teacher at Western Michigan University, where he received his B.S. degree (1957) with majors in Physics and Radio and TV Technology, with a minor in Mathematics. Upon graduation Mr. Thayer was recruited by a government R & D lab (HDL) in Washington, D.C., because of their need for personnel with expertise in electronics and physics. In 1962 he gave up his "Career Physicist" status to become a Peace Corps Volunteer science teacher in Malaysia, where he worked for two years.

Upon return to the U.S. Mr. Thayer studied for an M.A. degree in Science Education (Western Michigan '66) and began teaching physics at McKinley High School (D.C.) in 1965, where he stayed for 11 years, at which time he began teaching in the newly formed "Science/Math Program" at Ballou High School (D.C.) where he still teaches two levels of physics and a course in Engineering Concepts.

Between the years 1965 and 1972 Mr. Thayer received training at various NSF Institutes, including PSSC Physics, Harvard Project Physics, Engineering Concepts Curriculum Project and Chem Study.

At Ballou High School Mr. Thayer sponsors the Engineering Club, the "It's Academic" team, the Physics Olympics team and is Trustee of the Amateur Radio Station and satellite tracking facility. He is the school METCON (Metropolitan Consortium to increase minority participation in engineering) representative and coordinates several programs aimed toward METCON goals. He has taught in-service courses on "Computer Applications in the Classroom" and "Amateur Radio in Education". (He has other teacher-training experience at the former D.C. Teachers College and at the Peace Corps Training Center in Hilo, Hawaii). He is in charge of the wind and solar energy project installations.

Mr. Thayer is a member of the American Association of Physics Teachers, National Science Teachers Association, District of Columbia Science Educators Association, Amateur Satellite Corp., American Radio Relay League and Amateur Radio Research and Development Corporation. Some of the awards he has received include the Joint Board on Science Education "Outstanding Physics Teacher" award in 1971, Kiwanis Club "Outstanding Service as a Teacher" awardin 1980 and the District of Columbia Science Educators "Outstanding Science Educator" award in 1982.

Mr. Thayer is unusual in that he has gone against the flow of science and math teachers who leave teaching to enter industry or the government. A firm career choice was made, and the timing of support (NSF Institutes) was just right to encourage him to continue.

THE LASTING INFLUENCE OF NSF INSTITUTES

When I was asked whether I would like to participate on this panel I responded positively because I had been thinking for some time about the problems of science and math education.

In particular, I reflect now on the influence of government-sponsored programs on my own career. It is in fact very unlikely that I would be a classroom teacher today were it not for the training and inspiration offerred in several NSF-sponsored summer institutes in which I participated within the period between 1965 and 1972. These institutes addressed curricula in ways which met several needs of science teachers. Knowledge of the subject matter was strengthened, and skills needed to effectively facilitate laboratory experiences were upgraded. Since teachers usually must find summer employment to supplement income, the stipends covering tuition and living expenses were necessary to attract teachers into the programs.

I personally would not have attended the institutes without the stipend, in which case I would not have been trained to teach PSSC Physics, Harvard Project Physics or Engineering Concepts. It must be very frustrating to attempt to accomplish any task which requires training not yet acquired. I have seen physics teachers come and go during the post-institute period, some of whom might have stayed on had they received up-to-date skills training, encouragement and inspiration potentially available in a well-designed institute.

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John Thayer
April, 1983

DISCOURAGING OUR BEST

When I see Arthur Brooks, Marina Henderson (seniors at Ballou High School) and others on our "Physics Demonstration Team" present science demonstrations to the community I feel compelled to fantasize, envisioning them as classroom teachers... ..some of America's best, providing exciting and meaningful instruction to the young.....only a few years from now. It is a haunting thought, lasting only a few seconds. Does anyone encourage those who have obvious teaching talent to pursue teaching careers? The answer may be implied in another question: Would I encourage someone I respect to go into a profession not widely revered, where in many districts those with fewer than 5, 10 or even 15 years experience in their particular school system are threatened with possible layoffs?

The fact is that there is a tendency to steer our most talented young people into other professions: law, engineering, medicine, computer programming or almost anything else besides teaching. There is quite a dilemma facing teachers, parents and counselors. We want our young people to seek careers that will bring them status and money, so we guide them into those areas which will satisfy the criteria, even though it may be that one possesses unusual gifts (and even perhaps a hint of interest) which could be put to better use for the good of society in the science or mathematics classroom, or some other classroom. Defense-related opportunities abound, and are enticing. As one who has personally vowed to, as the old song goes, "study war no more" I feel somewhat torn as I write a glowing recommendation for a "natural teacher" to get a summer D.O.D. job where one of the main thrusts is to learn more sophisticated ways to "zap" people.

Further, everybody wants the "best". There is intense competition for those students who have done well in their science and math classes. We have been successful in steering our "natural teachers" on the physics demonstration team into engineering programs at West Point, N.C. State, G.W. and other reputable places of higher learning.

The question arises as to whether it would be a waste of talent for someone who could be a computer systems analyst, an astronaut or an advanced weapons system designer to be a science or math teacher in a school. It is not a waste provided the individual has the interest, ability and willingness to do what is necessary to succeed as a teacher. After all, does it make sense to assume that a skilled, knowledgable, inspiring science or math teacher will bear more fruit than someone barely knowledgable and not enthusiastic about teaching? If it is long term, productive results that we desire, it seems clear that we must find ways of identifying early those who have the potential for becoming excellent teachers and then providing the necessary incentive to pursue science or math teaching careers.

John Thayer
April, 1983

An NSTA Position Statement

Science-Technology-Society: Science Education for the 1980s

Preamble

Science and technology influence every aspect of our lives. They are central to our welfare as individuals and to the welfare of our society. All around us are examples of the importance of science and technology for production of food, shelter, clothing, medicines, transportation, and various sources of energy. There are an increasing number of science- and technology-related societal problems as well as increasing societal benefits. Science and technology are central to our personal and cultural welfare *and* to many societal problems. We must insure appropriate science education for all citizens.

However, the quantity and quality of science education for all people are not commensurate with the status of science and technology in society. When one would expect budgets, time spent on science-related subjects, and support for science education to be increasing, they are decreasing. At the same time these factors are declining, societal problems continue to require an understanding of science and technology. The burden of response rests heavily upon the shoulders of *all* persons associated with science endeavors—scientists, engineers, classroom teachers, other educators, and school administrators. Many of the problems we face today can be solved only by persons educated in the ideas and processes of science and technology. A scientific literacy is *basic* for living, working, and decision making in the 1980s and beyond.

There is a crisis in science education. The following science-technology-society problems demand immediate attention:

- understanding of science and technology are central to our personal and national welfare, yet public appreciation of science education has declined;
- increasing number of individual and societal problems which have an impact on the quality of life are related to science-generated technology;
- as the impact of science and technology on society has increased, the support for science education has decreased;
- compared to its recent past the United States has fallen behind in the production of scientific and technological goods and services; and
- women, minorities, and handicapped persons are under-represented in nearly all professional and technical roles in science and technology.

Declaration

The goal of science education during the 1980s is to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to use this knowledge in their everyday decision-making. The scientifically literate person has a substantial knowledge base of facts, concepts, conceptual networks, and process skills which enable the individual to continue to learn and think logically. This individual both appreciates the value of science and technology in society and understands their limitations.

The attributes listed below help to describe a scientifically literate person. Each attribute should be thought of as describing a continuum along which the individual may progress. The progress of the individual's science education should be equated with progress along this continuum.

The scientifically and technologically literate person:

- uses science concepts, process skills, and values in making responsible everyday decisions;
- understands how society influences science and technology as well as how science and technology influence society;
- understands that society controls science and technology through the allocation of resources;
- recognizes the limitations as well as the usefulness of science and technology in advancing human welfare;
- knows the major concepts, hypotheses, and theories of science and is able to use them;
- appreciates science and technology for the intellectual stimulus they provide;
- understands that the generation of scientific knowledge depends upon the inquiry process and upon conceptual theories;
- distinguishes between scientific evidence and personal opinion;
- recognizes the origin of science and understands that scientific knowledge is tentative, and subject to change as evidence accumulates;
- understands the applications of technology and the decisions entailed in the use of technology;
- has sufficient knowledge and experience to appreciate the worthiness of research and technological development;
- has a richer and more exciting view of the world as the result of science education; and
- knows reliable sources of scientific and technological information and uses these sources in the process of decision making.

Recommendations for K-12 Grade Levels

Elementary School Science

Science should be an integral part of the elementary school program. It should be used to integrate, reinforce, and enhance the other basic curricular areas so as to make learning more meaningful for children.

A carefully planned and articulated elementary science curriculum should provide daily opportunities for the sequential development of basic physical and life science concepts, along with the development of science process and inquiry skills.

Elementary science should provide opportunities for nurturing children's natural curiosity. This helps them to develop confidence to question and seek answers based upon evidence and independent thinking. Children should be given an opportunity to explore and investigate their world using a hands-on approach, with instructional materials readily available.

The focus of the elementary science program should be on fostering in children an understanding of, an interest in, and an appreciation of the world in which they live.

Middle/Junior High School Science

The middle/junior high school science curriculum should be designed to accommodate the needs and learning styles of the early adolescent. Students should be provided with daily opportunities to explore science through reading, discussion, and direct learning experiences in the classroom, laboratory, and field.

Middle/junior high school science should contribute to the development of scientifically literate persons and not simply prepare them for the next science course. National studies have shown that often middle/junior high school science is designed to prepare students for high school biology with no emphasis on physical science. In addition, studies show that fewer than one half of the junior high students going on to high school take chemistry and physics. Therefore, it is imperative that an important thrust of middle/junior high school science be toward the physical and earth sciences.

Middle/junior high school students should continue to develop science process skills and content. Middle/junior high school science should emphasize the *application* of both skills and content to the students' personal life situations and enable students to begin examining societal issues that have a scientific and technological basis. Middle/junior high school students need to *apply* what they have learned soon after their instruction to insure the lasting value of the experience.

High School Science

The high school science curriculum should enable students to further develop their scientific and technological literacy. Courses incorporating well-designed laboratory and field work help to meet this need.

A balanced core of two years of science should be required of *all* students, consisting of one year of life science and one year of physical science—both taught in a science-technology-society context. The courses should provide students with opportunities to develop skills in identifying science-based societal problems and in making decisions about their resolution.

Students interested in exploring or preparing for careers in science, engineering, or technical fields should have the opportunity to take additional discipline-based courses in advanced biology, chemistry, physics, and earth sciences. These courses should be planned and sequenced to take advantage of the students' increasing command of mathematics.

Time on science learning

- Lower elementary level (grades K-3): a minimum of 1½ hours/week of science should be required.
- Upper elementary level (grades 4-6): a minimum of 2½ hours/week of science should be required.
- Middle/junior high school level (grades 7-9): a minimum of 1 hour/day for at least 2 full years of science should be required of all students.
- Senior high school level (grades 10-12): a minimum of 1 hour per day for 2 full years of science should be required. The courses should represent a balance of physical and life sciences.

Emphasis on programs for all students

- In elementary, middle, junior high, and senior high school grades, science education programs should provide basic concepts for all students. Opportunities should be available for students with diverse interests and commitments, including students with exceptional interests and talents in science.

This NSTA Position Statement was adopted unanimously by the Board of Directors in 1982. Additional copies of this position statement are available; write to the National Science Teachers Association, 1742 Connecticut Ave., N.W., Washington D.C. 20009.

Emphasis on science education for the adult general population

- Schools should provide educational opportunities in science for all the adult population in their community.
- Colleges, universities, and national organizations should increase emphasis on science education for adults through public lectures and seminars.
- The important contributions of out-of-school education programs such as museums, TV, planetariums, and zoos, should be recognized and utilized by all those involved.

Emphasis on the professional development of science teachers through inservice opportunities

- Colleges, universities, and other agencies should develop teacher education and inservice education programs that are consistent with this policy statement.
- School districts should provide opportunities, encouragement, and recognition for teachers who maintain a high level of professional competence.

Emphasis of laboratory and field activities

- Elementary level laboratory and field activities should stress the development of basic inquiry skills.
- Middle/junior high school level laboratory and field activities should stress the application and extension of inquiry skills as a means of obtaining knowledge and resolving problems.
- High school level laboratory and field activities should emphasize not only the acquisition of knowledge, but also problem solving and decision making.

Science instruction matches students' cognitive, physical, social, and emotional development

- Schools should provide objectives, content, and instructional strategies that are appropriate to the student's stage of mental, moral, and physical development.
- Varying strategies and materials should be provided at all grades to accommodate students with various levels of learning skills and mental development.

Emphasis on science-related societal issues

- Elementary level: a minimum of 5 percent of science instruction should be directed toward science-related societal issues.
- Middle/junior high school level: a minimum of 15 percent of science instruction should be directed toward science-related societal issues.
- Senior high school level: a minimum of 20 percent of science instruction should be directed toward science-related societal issues.

The Committee to Develop the NSTA Position Statement
SCIENCE-TECHNOLOGY-SOCIETY:
SCIENCE EDUCATION FOR THE 1980s

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Senator HATCH. Thank you. We're pleased to have that.

Mrs. Howell, you submitted a formal written statement. Would you care to summarize that for us and we will put your formal statement into the record.

Mrs. Howell, by the way, is a classroom teacher of mathematics and science to the gifted at the Stratford Landing Elementary School in Fairfax County, Va.

STATEMENT OF KAREN J. HOWELL, CLASSROOM TEACHER OF MATHEMATICS AND SCIENCE TO THE GIFTED, STRATFORD LANDING ELEMENTARY SCHOOL, FAIRFAX COUNTY, VA.

Mrs. HOWELL. With your permission I'll make this a very brief comment.

Although I could have chosen other career paths in either science or math, my decision was to teach. While there are times I question my career decision, as we all do, I do not regret it. Many individuals chose teaching because career opportunities, especially for women at that time, were limited and they wanted to be sure of a job.

The same individuals today are not choosing teaching but are taking advantage of newly opened, more profitable career paths.

In my statement I covered shortage of materials, the necessary role of upgrading content skills—not just the methods but content. I covered incentives, personal tax breaks and special recognition for teaching performance.

As far as gifted education is concerned, two of the most important areas are the upgrading of teachers' skills. Many of the students who are not able to be included in gifted programs are in classrooms where teachers are not adequately prepared to meet their needs. Most teachers do need their skills upgraded, as well as needing additional materials to meet the needs of those children.

I believe the supply of high-quality teachers will continue to be limited until the standard rewards of the free enterprise system of compensation and recognition become available to the profession.

Thank you.

[The prepared statement of Mrs. Howell follows:]

Statement before the

Committee on Labor and Human Resources
United States Senate

April 18, 1983

by

Mrs. Karen J. Howell

Classroom Teacher of
Mathematics and Science to the Gifted

Stratford Landing Elementary School
Fairfax County, Virginia

Mr. Chairman and distinguished members of the Committee, my name is Karen Howell. I am a classroom teacher in Fairfax County and I teach mathematics and science to the gifted at Stratford Landing Elementary School in Alexandria, Virginia. My remarks this morning will be brief in order to leave more time for questions.

My background and experiences do, of course, have a great deal to do with what I have to say and my answers to your questions. After earning a Bachelor of Science degree from the University of Northern Colorado (double major in Elem. Ed. and Science; minor in Math.), I taught for several years in a disadvantaged neighborhood where a good portion of class time was spent maintaining discipline, protecting the students from each other, and imparting basic social skills. It was one of my most rewarding teaching experiences. In my current assignment, I teach mathematics and science to gifted elementary students as part of a team of three teachers. This, too, is a very rewarding and challenging opportunity. Finally, I am the mother of two recent graduates of the Fairfax County High School System.

I have been asked to comment on the legislative proposals you are considering and to offer advice on how to solve this country's pervasive problems of mathematics and science education. I cannot presume to do more than offer my impressions of the problem and tell you what, in my opinion, will work and what will not.

Computers in the classroom. Computers have captured the imagination of every child (and most adults) able to put twenty-five cents into a video game machine. In the classroom we are able to take advantage of that interest to teach decision making and logic at the same time we are teaching math skills or spelling or whatever. Computers have a double value because they can be used as teaching machines while also serving as examples of organization, logic and decision making. (They are much less fallible in this regard than we mortals.) Computers are definitely needed in the classroom at all levels.

Use of the skills already available. We are very fortunate in Fairfax County to have a special program for the gifted which is built around a center concept. In each area qualified students go to a designated "center" school where the gifted program is provided. At our school I teach all the mathematics and science to the fourth, fifth and sixth graders. The advantage is obvious. I know all the skill levels of the students and have three years to move each of them as far along as they are able to go. The students understand my particular methods and less time is lost trying to "figure each other out". At our school, one teacher with the interest and qualification to teach math and science, does what it takes many to do, working part time, under different systems.

Retraining teachers and other incentitives. There is a popular misconception that teachers work eight to five for nine months and then have the summers free. Programs to support in-service training or summer school courses will not be automatically welcomed if it is assumed that there are no competing activities. The fact is that the summer break is generally only eight weeks long and about one-half of my weekends and evenings during the school year are devoted to grading papers and other school work. However, many elementary level teachers must have their science and math skills (not methods of teaching) upgraded. Therefore, in-service courses should teach skills. They must be worthwhile, both while attending, and in terms of application afterwords; and some additional motivation must be provided. I am not in favor of salary differentials because of the subject taught. To differentiate on that basis would undermine the very necessary cooperation and team spirit essential in the schools and would result in persons electing to teach math or science for the wrong reasons.

May I suggest that a federal program that provided optional examinations to teachers who wish to be recognized as "master teachers" might be an answer. A "master teacher" program could be established first for mathematics and science teachers and carry with it either a cash award or a salary differential. Such a program would allow teachers who do not wish to become administrators at least some career opportunity without forcing them to give up the classroom.

Personal Tax breaks. When I was teaching disadvantaged children just after I graduated, my income was very low but still I found myself spending my own money on teaching aids, supplies and so forth. My tax bracket was also low so I didn't get much of a refund for these expenses. We are now a two-income household and both our tax rate and our ablity to spend money for equipment and supplies are higher. I would like to suggest that a way be provided for low income teachers who spend their own money on science kits to be paid back completely up to a reasonable ceiling.

Special Recognition. When our students do particularly well, we reward them with some form of recognition. It doesn't cost us anything. No special funds are needed. It would be very motivational to all the good teachers (who generally are only recognized by parents when something is wrong) to receive some sort of Congressional or State certificate of appreciation. I am sure that an uncomplicated system could be set up so deserving teachers could have something to put on the wall that let the parents and the students know that their Senator supported superior performance.

I would like to close with a personal observation. I was fortunate enough to be able to choose almost any scientific career path I wanted. My decision was to teach and, while there are times when I question that decision as we all do, I do not regret it. Many of my classmates in college chose teaching because career opportunities for women were much more limited and they wanted to be sure of a job. Those same women today are not choosing teaching, but are taking advantage of newly opened career paths. I believe that the supply of high quality teachers will continue to be limited until the standard rewards of the free enterprise system - compensation and recognition - become available to the profession. Thank you very much. I would be pleased to answer your questions.

Senator **Hatch**. Thank you. Are there any other statements before I ask some questions?

Ms. Nussbaum.

STATEMENT OF PATRICIA PANTANO NUSSBAUM, TEACHER IN THE MONTESSORI PROGRAM, JOHN BURROUGHS ELEMENTARY SCHOOL, WASHINGTON, D.C.

Ms. **Nussbaum**. Before I begin to talk about my statement I would like to tell you that, although I teach in the D.C. Public School System, the method of education that I employ is the Montessori method. All my background in education is from that. In my building there is a Montessori method alongside the traditional program.

I think that I would like to mention here something that Mr. Keyworth touched on and that is the raising of the standards of achievement for the children. If we can look at what makes a successful learning environment for the child, what the child needs, then I think a natural outgrowth of that is that his achievement level can be raised.

Through the Montessori method we have found that if you provide a child with the opportunity for concrete, individual, hands-on experience with materials before presenting an abstract concept, and if you give him a chance to use those materials freely, not on a structured timetable, as he wishes, during the course of the day or the week, and if the teacher becomes to him a guide to that material, rather than just a disseminator of information, we have seen that children at a very early age are early to learn concepts that normally are saved for later in life.

One of the key components to the Montessori program is to begin children at the preschool level, so that when he comes to the elementary level he is already reading and able to begin abstraction math processes. What this means is that the elementary level child, who is really open to discovery, is not hampered by having to learn how to read and compute. He's already got that behind him; he's learned it in the preschool stage.

We have seen that giving the child the opportunity for preschool and giving him the type of environment such as Montessori offers automatically results in raising the standards of achievement.

[The prepared statement of Ms. Nussbaum follows:]

TESTIMONY

SUBMITTED TO THE

SENATE COMMITTEE ON

LABOR AND HUMAN RESOURCES

BY

PATRICIA PANTANO NUSSBAUM

TEACHER IN THE MONTESSORI PROGRAM

JOHN BURROUGHS ELEMENTARY SCHOOL

WASHINGTON, D.C.

INTRODUCTION

The critical inadequacies of today's children in math and science are deeply rooted in a complexity of problems facing American educators. The fact is that by international comparison, American children in general, for their high standard of living and access to technology, cannot compete with those of other industrialized nations. We must find a way to tap the inherent potentials of our children, and the solutions we seek stand to shake our educational system at its very foundation. We must begin now to fundamentally address this problem by offering immediate remediation for our current student population and at the same time aiming for basic, long-term solutions.

I. Needs of the Child for Successful Achievement

A. The Learning Environment

Foremost to the success of any math and science program is the opportunity for the child to have a concrete, individual, "hands-on" experience relating to the concepts to be taught. This must be provided with a balance of structure and freedom so as to allow for useful observation and discovery. For example, in learning fractions, we give identical units cut into fractions for the child to see, count and manipulate. Such apparatus should be made available for all concepts the child is to abstract and internalize.

The teacher's role should be seen as one of facilitator, rather than disseminator of information. She must be confident and enthusiastic in her approach, always encouraging the child to find out for himself. (Returning to our example of fractions, she could show how two-fourths fit in the space of one-half and then ask: "What else can you find that would fit there?") Furthermore, it is essential that the teacher be able to integrate math and science into the subject areas of reading, language, history, geography, music and social studies.

The children should be able to work on their own daily time-table, and at the subject of their choice, provided they cover the basic requirements of the curricula. In this way there is always a variety of work going on simultaneously in the classroom which promotes sharing and exchange of ideas. The child is allowed then to follow a problem that interests him to its satisfaction and solution.

These are the major factors in stimulating and developing the child's natural curiosity and drive to order and make sense of his world.

B. Pre-School Education

Although it may appear irrelevant to the discussion at hand today, we must here make a case for the availability of quality, pre-school programs by public school districts. No abstraction or theory can be made without a basis in fact, and the period from age 2½ to 6 is the optimum time for learning language in general, and language of fact, in particular. This can be related to color, number, comparisons or classification. Such acquisition is made without effort by the pre-school child and his capacity for vocabulary knows no bounds. In addition, basic mathematical concepts, including processes and operations, as well as reading skills, can, without coercion or "drill," be acquired by the age of 6. Thus it is that a Montessori pre-schooler enters the elementary class as a reader, on the verge of abstracting addition and subtraction, able to classify groups of the vertebrate animals: a keen observer, comfortable with concepts of comparison.

The long-term advantages of a quality education at the age of 3 - 5 is well documented.[1] From this kind of foundation the Montessori child can eventually, by age 12, be exposed to advanced work often presented to the average child for the first time in high school.

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[1] McNichols, C."Effects of Montessori School Experience," Young Children. July, 1981.

Miller, L. and Dyer, L. "Four Pre-School Programs," Society for Research and Child Development, Monograph. 1974 - 1975.

Miller, L. and Jones, B. "Four Pre-School Programs: Their Lasting Effects." Erik Document. # ED 171415.

C. Raising the Standards of Achievement

Hopefully, it has been made apparent thus far that by providing children with the opportunity for pre-school education and learning environments which employ those principles and materials suited to his needs, what follows as a natural and enthusiastic result is a higher standard of achievement. The child has shown us repeatedly that many of the standards we set are below his capabilities. Regarding this issue, reference has been made to the Montessori method because it has proven more successful in many cases than the traditional methods of education. There are now 57 public schools in 12 states (as well as hundreds of private schools) which implement this method on a large scale, some of which show excellent results.*

II. Needs of the Classroom Teacher

A. Problems Encountered by Current Teachers

Speaking from my experience as a Montessori teacher and in speaking to those who do not employ Montessori, I find there are common concerns, the most urgent of which are:

1) need for in-service training of current teachers, and
2) lack of resource or specialty teachers due to: a] inadequate funds for hiring at competitive salaries

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*The MacDowell Montessori School in Milwaukee, which is racially, socially and intellectually balanced, reports that their children ranked second in the city on the ITBS, topped only by those children enrolled in the gifted and talented program. Similarly, the Sands Montessori School in Cincinatti which ranked 30th and 40th out of 76 in reading and math respectively in their pre- Montessori days, now ranks 2nd and 3rd. Their enrollment includes a city-wide population of children (43 per cent of whom are welfare recipients) and handicapped and learning disabled children.

b] shortage of qualified applicants

3) lack of basic equipment and materials with which to present concepts and provide follow-up work.

In a world where technological and factual information accumulate and develop and change at such a rapid rate, the resource teacher becomes the key source of information, a link, as it were, between the teacher and current advances in the field. By the same token, however, teachers with special interests, or particular weaknesses, also need the opportunity to enrich and update their knowledge and technique.

It must be emphasized here that to provide for any of the above needs (in-service training, equipment or resource teachers) in isolation is to render the others useless. A teacher, inspired by a workshop, eager and enthusiastic, but having no access to proper equipment, becomes frustrated. A laboratory of highest quality, without the guiding hand of a qualified teacher, remains lifeless. A resource teacher who puts children in contact with his subject on a weekly basis without facilitating classroom opportunities for repetition and application only serves to relegate the concepts out of the real world of the child's interest and imagination. Thus, there is established a cycle by which many potential math and science achievers are thwarted. Few children pursue math and science courses in high school and even fewer consider it as a career.

B. Future Teachers: Incentives and Training

The education of our children, which calls for the most qualified and competent personnel, often loses such professionals to fields that offer more lucrative salaries. This applies to teachers in general and to specialized teachers in particular.

Staffing problems are better resolved by providing compensation comparable to that of business, government and industry, than by funding scholarships for teacher preparation. When payment of scholarships is in the form of required service, the most competent teachers move into other professions after that period of service. That is what causes our current shortage of personnel.

Regarding teacher preparation, we must refer to those methods cited which promote the success of the child. If we are to promote higher standards for our children, teachers must be comfortable in a methodology that allows the child individual experience and intellectual freedom for discovery. In the areas of math and science particularly it is essential that children come out of their textbooks and away from their desks to see what the wider world has to offer. The teacher must be his enthusiastic guide.

III. Recommendations on Government Funding Proposals

A. Proposals Affecting Current Students and Teachers

Monies need to be available as suggested in Part II A, i.e., for equipment and materials; for in-service teacher training; and for hiring resource or specialty teachers. These should be available directly from the Federal Government to school districts as needed, in part or in total.

The government is not in a position to mandate higher standards of achievement but could well promote them through incentives. For example, a school district (or a particular school or region in that district) could submit a five-year plan for improvement of science and/or math, including a curriculum and the level of achievement anticipated. After the two years, the plan is reviewed and funding continued, based on the results.

Other options include: grants to colleges and universities to develop programs for current teachers, especially in areas where technology is being introduced and updated; tuition grants to teachers to take such courses; providing money for salaries or salary supplements to highly skilled specialists in teaching. It must be emphasized that the administration and monitoring of such funds require a minimum amount of paperwork on the part of the teacher so that his performance in the classroom is not compromised.

B. Training of Future Teachers

Here again, the government cannot and should not make requirements on the qualifications for teacher certification. Yet, in view of the need for a teacher training program that is more in line with the needs of the child, monies should be available to colleges and universities for the purposes of studying and developing successful programs and ultimately implementing them.

Finally, we must encourage future teachers with assurances that they can acquire a decent standard of living for themselves and their families in the teaching profession. This requires giving to education the priority in both state and federal budgets that it deserves.

Senator **Hatch**. Thank you.

Mr. Goffredi, as I understand it, you're the chairman of the department of mathematics at Wakefield High School in Arlington. Do you have a statement?

STATEMENT OF LOUIS GOFFREDI, CHAIRMAN, DEPARTMENT OF MATHEMATICS, WAKEFIELD HIGH SCHOOL, ARLINGTON, VA.

Mr. **Goffredi**. Senator, I think a couple of the points that have already been mentioned, dealing with salary, summer jobs the teachers wish to get every year—I've been teaching 17 years and am pleased to say I think I have my summer job already lined up this year. The problem with that is that teachers don't have the freedom to take courses for their enrichment, to take courses that will give them better preparation for the new materials, and for the new approaches to mathematics that we have today.

The computer era is upon us. When I went through college—I graduated in 1966 from college—we didn't have microprocessors. I've had to piecemeal, on my own, take a course here, a course there, whenever I could afford it, when time constraints allowed me to afford it.

During the summer I have to get a job. I have a family. I have a child. We have a mortgage. It would be nice just to have a scholarship to go to American University or Maryland University, but the scholarship doesn't pay for my mortgage. It doesn't pay for our clothing or the rest of our summer vacation, as it's called. That's sort of a misnomer because my salary is based on a 200-day calendar. If I miss a day I'm docked one two-hundredths of my pay, so, I'm yet actually to get a paid vacation while teaching. That's, as I say, a misnomer. It's a misconception that people have. A teacher's salary is for the time that they are teaching. Trying to go to school during the school year, trying to take classes at night—I have a family, I also have to correct papers. I have to correct the papers. I have to grade the papers. I have to evaluate the students and prepare my next day's classes—next week's classes. These are things that have to be addressed when we're talking about continuing education for teachers and attracting people to the teaching profession. When someone coming out of school or someone who is currently in school hears from the newspapers, the media, et cetera, that teachers are generally the low-end of their class, that persons that are enrolled in education courses are primary the lower levels of the university student body, they're not real anxious to join that group. It's not a nice thing to go into a group that's already labeled as being the dummies.

In our work people continually ask me when I'm going to move up to become a principal. That's a totally different branch of work; it's not teaching; it's not educating students. You hear about a principal who moved back to the classroom. These are just attitudinal image presentations that teachers live with every day. This lack of recognition of the importance of our job—image in general—is what teachers are fighting.

Currently one of the big proposals in northern Virginia is to go back to the closed campus. Well, the closed campus, in this day and age, is a rather difficult thing to define since we have so many programs for students who are outside the actual building. What this amounts to in essence, or at least their explanation for why they should do this, is they really are trying to keep the schools as detention centers for the people that they feel that are going to be out in the community shoplifting and doing damage. These are things that teachers wonder about. Here we're told we're supposed to be educating students and yet they want to put into the classroom—the courts in situations have complained to the schools that they've kept this young person from receiving an education when that young person has just finished being involved in drug dealings, in the school, and the school has suspended them indefinitely. Well, a 3-day suspension is the maximum and they're back in school. This tends to weigh down the teacher. It tends to weigh down the impression of the school. It tends to keep us from performing our tasks at the optimum. There are many, many things that I would like to be able to say. There are many things that I think can be done to improve the education of our schools—of our students.

There are a lot of problems that have to be addressed and it has to start at the local level. I hope that some guidance from the upper levels will begin here in this committee.

Senator HATCH. Thank you, Mr. Goffredi.

Miss Brown, Miss Iona Brown, is a math teacher at Paul Junior High School, Washington, D.C.

STATEMENT OF IONA BROWN, MATH TEACHER, PAUL JUNIOR HIGH SCHOOL, WASHINGTON, D.C.

Miss BROWN. Yes, I have some students here from Paul Junior High today.

Senator HATCH. We're happy to have you Paul Junior High students with us.

Miss BROWN. I have no formal statement. I began to prepare something and then I read the issue brief and found that most of what I had said was covered in that brief, so I don't have a formal statement.

I'm very much aware of the problems in math and science. I think part of our problem in math and science—unlike other fields—is that teachers are assigned very often to mathematics simply because they know how to add, subtract, multiply and divide. Currently in our school we're short a math teacher and the business teacher—or a business teacher—was selected to assume the role of a math teacher for the various math classes. A science teacher had to be relieved of her responsibility because of a reduction in force, so a physical education teacher who had some science courses was then assigned several general science classes.

I think this points out one of the problems we're now having with children not doing very well in math and science nationwide. I am a product of having received the National Science Foundation grants for 3 years, and I am a strong advocate of the program that they have. I certainly think that in-service training would be one of the things that we need to update math and science in our schools. Teachers definitely need the in-service training that the National Science Foundation could afford.

Senator HATCH. Thank you, Miss Brown.

Mrs. Mitchell is a fifth grade teacher at the Rock Creek Forest Elementary School, Silver Spring, Md. We're happy to have you.

Mrs. MITCHELL. Thank you. I'm happy to be here and I have some of my fifth graders here today.

I did not prepare a formal statement, but I do have a few things that I want to comment on. First of all, I might say, I am pleased with some of the new developing things that are going on in our county, as far as curriculum for math and science goes. Our specialists have seemed to have identified and seen, as you do, that we have a real need to improve math and science in our county.

The curriculum for math has been introduced to my school just last year. We are given a whole new guide by which we teach. We are given a whole new system by which we grade assess our students. We have math cards by which we keep a record of each child's individual performance. I am very pleased with the way the curriculum was written, and I think it is a very, very good system.

I do have some concerns with this—I'm just going to share this with you because I want you to see that there are some positive things going on. But there are problems in ours in that there is a tremendous amount of time involved in providing for the curriculum development and implementing the development into the classroom with the day-to-day work.

The way that our system is set up, within a year or two we should be on a computer—we will one day have a math aide for each school who will be involved in doing a lot of work—assessing work—with the children. It's paperwork that takes a lot of time. If you give the time to the paperwork the time is coming out of preparing for other things. There is a good goal and I think once we get there with our math curriculum it will be very good. The problem is that we're implementing a program right now, in my school, that we're not really ready to do in complete form.

I'm seeing this also with science. We have a new curriculum that has just been written. My school is not on the science system, but I was able to get hold of the new guides and I read them. I'm very pleased because of the expectations that have been changed for the children. I'm happy to see that people have recognized, due to television, due to whatever media, children have much more sophisticated knowledge of science as they're coming to school. I think we were spending a lot of time teaching things that children really knew. So there has been an upgraded system there.

As I read through the guide I was very excited as to what I will be teaching 2 years from now. I will not implement it at this time but my feeling immediately was where will be the materials that I will be teaching these concepts with. I think that is my main concern. There is a need somehow—I don't know whether it's through a Federal grant or at local level by the State—assuring that teachers do receive materials, an aide, things like this to help them implement programs. Again referring back to math, I went to many math workshops to help me understand this new curriculum system and they were great. The workshops were very interesting and I learned many new ways to help children truly understand fractions, truly understand decimals and things. When I go back to my school I don't have the materials that they used at the workshop, so there's a need for some kind of coordination between curriculum and materials available. I am sure there are at some schools wonderful materials in boxes somewhere that teachers have no knowledge how to use because they didn't go to the workshop that I went to. There's a definite need for some sort of coordination.

I would also say that particularly in the areas of math and science there are needs for aides—an extra person to be available. I can stand in front of a classroom of 34 students and easily teach language skills and possibly social studies. When it comes to doing math and science we need a true manipulation of materials. You have to have another person there or you need to change your program, if the children are to look at science as more than a vocabulary list, if they're going to get into analytical thinking. If you can do science very well I think it's going to automatically carry over to mathematics. Recently there was an article in the paper regarding the problem that high schoolchildren are having with math problems. Their computational skills are great but to do math problems seems to be very difficult. I think if we can improve science and analytical thinking, comparing, inferring and predicting, it's automatically going to carry over to problem solving.

One other thing I wanted to refer to. I know there are a lot of thoughts on teacher grants and scholarships or scholarships for college students who show an interest in getting into teaching who have a background in science. I think that's very good. I do have just one thing I might mention about that. I know the teacher field is very closed as far as new graduates getting into the field. I might suggest that a look be taken as far as giving the scholarships and grants to already employed teachers, as much as possible, because they are already in the system. They will therefore be able to share their skills with students. I know of young teachers who graduated recently, science majors, who wanted to become teachers and took education courses. They cannot get a job because of the surplus and things like this. There are people out who are available and who do have skills but cannot be hired.

I think there's a real need to deal with what is in the school system now.

Senator HATCH. Would you say there's another need too, and that is that we need to train and retrain teachers?

Mrs. MITCHELL. Oh, very much so. Particularly in science. I don't know about math. I find that most teachers can open a math guide, if they have to teach a new skill, and feel a little bit comfortable with it. In science if a teacher doesn't have the skill I know many teachers will not do anything more than use the book. If a teacher brings out material, does an experiment and it fails, the teacher is often embarrassed and that is the end of science for the year.

Senator HATCH. I see a lot of heads nodding favorably to what you've said there. Yes, go ahead.

Miss BROWN. I might add something. Mrs. Mitchell mentioned that there was an article recently which said the students are not doing verbal math problems well. I think part of the reason children don't do math problems well is that the teachers don't know how to teach math problems.

Senator HATCH. This retraining would help.

Miss **Brown**. Definitely. It's more than computation. I think the problem with mathematics now is that everybody thinks of it as addition, subtraction, multiplication, and that's it. Children are doing better now computationally, but they're not able to analyze because their teachers are not able to teach them how to analyze.

Senator **Hatch**. I appreciate those comments. Our last witness here this morning is Mr. Clinton Brown, who is chairman, science department, Richard Montgomery High School, Rockville, Md.

Mr. Brown, we're happy to hear what you have to say.

STATEMENT OF CLINTON BROWN, CHAIRMAN, SCIENCE DEPARTMENT, RICHARD MONTGOMERY HIGH SCHOOL, ROCKVILLE, MD.

Mr. **Brown**. I thank you for the opportunity of being here. This is exciting to me. I speak best when I have a piece of chalk in my hand and a blackboard behind me, so if I stammer a little bit I ask you to forgive me.

I read through the brief, which was quite interesting, going through all the proposals in the H.R. 1310. It was quite comprehensive and it was as if someone was standing behind me watching the teaching and what has occurred in the school system for the past 10 or 15 years. It was good to see how accurate it was. As I went down through it there were a couple of factors that I would like to speak to in a precautionary manner.

No. 1. The in-service programs have been mentioned and effective teaching really depends on three interrelated factors. One is knowledge in a subject area. The second is teaching techniques. Being able to communicate the knowledge which a teacher has. The third one is behavior management. If a teacher can't keep the 34 students in their seats all the techniques and all the knowledge is not going to be helpful to those students. I see it as a threefold teacher effectiveness.

The in-service program addresses, many times, the techniques and behavior management but is weak on the knowledge area. College courses are very strong on knowledge area and miss the other two. If we could find a common ground between those it would probably address the issue better.

There was mention of loans and scholarships for students going into science and math and especially teaching. A payback time of approximately 3 years was mentioned there. I would encourage consideration for a longer period of payback time, possibly a year per year or even a year and a half payback time for every year in school. Mainly because it takes a long time to know whether you can be a teacher—an effective teacher. It would take 4 or 5 years for someone to develop the skills to teach correctly.

There was mention of new curricula packages for science and math. During the late 1950's and the early 1960's there were several very good curricula packages put out. The BSCS biology, the yellow-blue-green, the chemical, the chem study approach, chemical bond approach, the PSS physics, the Harvard Project Physics, all of those were excellent packages. Tremendous new materials on the market. A lot of money was made available to schools to purchase material. Many schools now have that sitting on the shelf because of the conflict between the ideas it taught and what the SAT tests and the college achievement tests measure. Those particular packages are good on inquiry and discovery approach. It teaches students how to think and how to analyze. How to get into an experiment and find an answer. Then when they take a SAT test, it asks for factual memorization. Students begin to fall down in scores. They were still being educated. They were still doing very well but they weren't being asked the material which they learned. We have been encouraged to teach to the SAT and to the college achievement, as well as to the advance placement tests, which are much more factual memorization.

There was mention of joint staffing between professional organizations and schools, which would be excellent, except that a person extremely knowledgeable in physics or chemistry walking into a school might be very weak in behavior management techniques and also teaching techniques and find it very frustrating to try to teach a group of students, as well as a teacher walking into industry needing training to do that particular job.

There was mention of industry allowing teachers to increase their skills either after school or summertime, as working part time, and the industry being given a tax break or—some type of a tax break because of that.

As was already mentioned on this panel, many teachers already have a second job and they need it for financial reasons. Unless the job offered by industry paid the same or was as mentally challenging, I don't think the teachers would give up the good job they now have to do the job with industry.

There was mention of teacher awards, which are very good and all teachers would like to be rewarded. Sometimes the award is given to a teacher not because of classroom effectiveness, but because of time put into publication, community relations and being visible to the community. That time, sometimes, is taken away from the classroom. That teacher has not done as good a job possibly as the teacher next to him, but the teacher next to him hasn't published or been on community panels. Then the teacher more visible receives the award and it could have an opposite affect. The teachers could teach less because they see a teacher not doing as well rewarded.

There was mention of high school science and math requirements being too lenient. I highly reinforce that. I think in Montgomery County, as well as the State, it only takes two credits of science to graduate from high school, and it can be any two credits. I could take a credit of horticulture, a credit of environmental science and graduate with an academic degree—and go on to college. I would encourage some type of an increase in what is required, and even what courses are required to graduate from high school with an academic degree.

If all of these programs are successful, and we do increase science and math training of teachers, we do increase students wanting to go into science and math teaching, we may find on the other end we haven't solved the problem because we still have a great disparity between industry and technological salaries and science and math in high school. In the 14 years I've taught I've seen 3 excellent physics teachers leave the school system. Two of those because they were drawn away by salaries equal or better by industry, the other one is retiring this year at the age of 65. Two chemistry teachers that had masters degrees in chemistry left for industry. All of the people who replaced them were not trained in the areas that these teachers taught, and are now getting trained. As soon as they are trained there's no stopping them from going on to the better salary.

I appreciate the time I've had to speak.

Senator HATCH. Thank you. I think each of you has added a great deal to this discussion here today.

Let me just ask one question to those of you who would care to respond. Is it your experience that the interests of both boys and girls in science and math is the same? Is there a marked difference and if so, why do you suppose there is? How can we get kids interested in math and science in these modern times?

Mr. GOFFREDI. I'd like to speak to that a little bit. Currently I think the emphasis where the acceptance by girls and boys of taking math courses, being in math courses, succeeding in math and science courses, is much better than it has been. I remember when I first started teaching, frequently a girl would not want to do that well in a math or a science course because of a stigma attached to it. It wasn't a feminine-type thing. I think now that's changed, at least to a good degree—some degree, so that women are now going into the sciences with much more enthusiasm than they had before, and it's a much more accepted thing.

Senator HATCH. I was the coauthor, along with Senator Kennedy, of the women and science program in the National Science Foundation. I really believe that we ought to be encouraging our young women to get into science a lot more. It's really a place where they can make a tremendous mark. Today there is such a dearth of young people who really are getting into science. There's a lack of teachers in the field, although you've indicated there may be some who could teach if they were just given the opportunities, which was interesting to me. I would like to know a little bit more about that. If you would care to write to the committee, we would love to have whatever information or insights you can give us. We're finding across this Nation there is a lack of math and science teachers as well as other technical personnel. I'm convinced if young women really want to make their mark in society today, the science field is one of the best areas where they can, where we are working to take down a number of roadblocks to their career opportunities. Part of that is also teachers. Teachers need to help young women understand that and, of course, at the same time they'll help young men too, because a lot of young people who have the capacity of doing math and science work really don't go into it because they're not encouraged. Or, they think it's too tough, or they don't want to put in the work. They don't realize that the rewards at the end of the line are very, very good. I think we need to have some educational process that helps young people to realize how important math and science really are to this society.

I'm sorry to have interrupted you. I was interested in those particular comments. I just wanted to make that point.

Mrs. HOWELL. I would like to add that as far as the elementary level, I feel that it is both boys and girls seem to have the same interests, but it really depends upon the teacher—her skill and her ability to get the children excited in those areas. As mentioned before, the teachers do need further training or upgrading of their own skills. It's very difficult for a teacher to get them excited or to encourage children if they themselves do not know the answers. I do not feel that just being able to open a teacher's guide will allow you to do that. They need to understand much more fully than just the guide would allow them to do.

Senator **Hatch**. You would agree then with training and retraining of teachers?

Mrs. **Howell**. Definitely.

Senator **Hatch**. Training that would enable them to become more proficient at teaching math and science?

Mrs. **Howell**. Yes. I think that once the children are very interested at elementary level, it will continue. Many of them because of the poor concepts they get in math and science at the elementary level when they go on to junior high and high school they have lost the interest. They may take the courses and with the big gaps they have in their basic background they can't comprehend what's presented at that higher level.

Senator **Hatch**. Thank you.

Mr. Thayer, did you have a comment?

Mr. **Thayer**. Yes. At our school, Ballou High School, we have a special program for science and mathematics. About one-fourth of the school is in the program. It's a 2,000 student comprehensive high school except for that group of 400, 9 through 12. We have equal numbers of women and men, and women do pursue scientific careers. I noticed today that Arthur Brooks and Maria Henderson are here. They are leaders of our physics demonstration team. which demonstrates—presents demonstrations to the community. Here are two people who are what I would call natural teachers. I find it discouraging to hear that someone who is trained and wants to get into teaching, in a critical field, can't do it. I, myself, don't want to really encourage someone I respect to go into a profession not widely revered, and where in many districts with 10 or 15 years of experience they may even experience layoffs.

I would like to see if there's a way where someone like Arthur and Maria could be encouraged to go into teaching. They won't—they'll become engineers. What will happen if we just retrain and we don't have any fresh, exciting, enthusiastic, young people coming into teaching in critical fields? Is there any way of dealing with that situation?

Senator **Hatch**. Well, we'll have to look into that.

Let me ask another question. This will be the last one I'll ask the panel. Do you teachers feel, and do your friends and colleagues in the profession feel, that you're getting sufficient support from parents and from communities in the area of math and science?

Mr. **Goffredi**. We're getting a lot of questions about will we be able to handle it. In terms of support we're being asked: Can you really teach our kids about computers? Can you really teach us what we want?

Senator **Hatch**. This is what the parents are asking?

Mr. **Goffredi**. This is what the parents are asking, and very reasonably they're asking that, because it's been mentioned that a person going through a university with knowledge in computers or in science will very readily go toward where they can make a sufficient salary. The salary scale in Arlington is one of the high salary scales in Virginia. The starting salary is $14,000 for a first year teacher with a B.A. After 15 years of teaching, with a master's degree, the salary scale stops at $29,000, which sounds reasonable, but you're talking about waiting 15 years to make $29,000. They know very well from their friends and their contemporaries that they can be making that much in 2 or 3 years in many of the computer areas. Right now, that's a problem in us getting the teachers— fresh teachers—as has been mentioned that are capable, that are well trained, that are well prepared. It really does hinge on salaries in that case.

Senator **Hatch**. Those are very interesting comments. Mrs. Mitchell, we'll make you the last commentator this morning.

Mrs. **Mitchell**. OK. I just had to comment in regards to parent and community involvement. It was mentioned earlier that the education begins at home, the community and things like this. I would say just as regards my children, if anyone in my class does not perform well in math, they take a report card home that does not have a good grade, I will definitely speak with the parents, but if I did not they would come to me. But generally if a child does poorly in science, that's just science, the parents do not seem to be concerned. I don't know if science is looked at as a career, and if my child is not going to be a doctor or whatever, it's just not looked at as reading and math. Reading and math are the main concerns. For some reason science is just not looked upon as important as the other subjects are.

Senator **Hatch**. Miss Brown, I could tell you wanted to say something so we'll make you the last one.

Miss **Brown**. I wanted to just address this thing about parental support. I think part of the problem that we have in mathematics today has been caused by parental pressure and what is now popular. We were in a stage of new math, in quotes, at one time and parents weren't able to understand what their children were doing. Then there was this back to basics cry, and as a result of children doing only basics now we find another deficiency—they can't analyze and they can't do verbal problems. I think we have to take with a grain of salt sometimes what parents want for their children. They don't always know what's best.

Senator **Hatch**. This has been a tremendous panel. I really appreciate all of you taking your time to be here. I really appreciate all the young men and women who have attended today. They've really been tremendously well behaved and I commend all of you as teachers for the job you are doing. The comments that you have made have been very enlightening to us. It's good to hear from people who are right there in the front trenches meeting these problems day in and day out. These bills, we hope, will be extremely important, and will result from the best possible thinking we can get.

Your testimony today has been not only practical, but educational for us. Let's hope that we can fulfill some of the mandates that you've given to us.

Thank you so much for coming. We appreciate it.

Our third panel consists of representatives from scientific societies, which are important groups because it is their members who are the working scientists in industry and universities and who are responsible for America's preeminence in science and the strength of American industry.

Tomorrow's scientists and engineers will come from today's grammar and high school students. Therefore, I believe that the scientific societies have a vital role in assisting the education of these youths.

I welcome Drs. Hogan, Parry, Flint, and Boehm. I very much welcome their views on the important issues before us.

Both Dr. Parry and Dr. Boehm are from my home State of Utah. Dr. Joseph C. Hogan is dean emeritus, School of Engineering, University of Notre Dame. He's here on behalf of the National Society of Professional Engineers and the National Society of Engineering Education.

Dr. Robert Parry is a distinguished professor of chemistry, University of Utah. He's here on behalf of the American Chemical Society.

Dr. Franklin Flint, chairman of the department of biology, Randolph-Macon Women's College, Lynchburg, Va., is here on behalf of the American Institute for Biological Sciences.

Dr. Robert F. Boehm is chairman of the department of mechanical and industrial engineering at the University of Utah. He's here on behalf of the American Society of Mechanical Engineers.

These societies know how to put the pressure on me in having my fellow Utahans here to be with us. We're happy to welcome all four of you here today.

I have a problem. I have a chairmen's meeting at 12 o'clock. I may have to submit written questions to all of you, but I'd still like you to summarize your statements as best you can. That will give me 2 or 3 minutes to get over to that chairman's meeting. It was a quickly called meeting but I better be there.

Shall we start with you, Dr. Hogan?

STATEMENT OF DR. JOSEPH C. HOGAN, DEAN EMERITUS, SCHOOL OF ENGINEERING, UNIVERSITY OF NOTRE DAME, SOUTH BEND, IND., ON BEHALF OF THE NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS AND THE NATIONAL SOCIETY FOR ENGINEERING EDUCATION

Dr. HOGAN. Thank you. I'm very happy to be here, Senator Hatch. I'm here on behalf of the National Society for Professional Engineers.

Senator HATCH. We will put all of your statements in the record as though fully delivered.

Dr. HOGAN. I'm here on behalf of the NSPE and the American Society of Engineering—Engineering Education. We very much support your efforts on the precollege science and math program. Dr. Knapp earlier talked about a continuum of education. That is one of our principal concerns, that we not only worry about the math and science precollege education, but also what happens to these students as they come out with an increased interest in science, in mathematics and hence have a capability for engineering education. We have a problem that exists right now and that is the capacity of engineering schools throughout the Nation is already exceeded.

We have an engineering faculty shortage that is well documented by reports and in the formal part of the report. We have teaching loads that have been greatly increased. This has caused time pressures on faculty in that they've been unable to do research that is needed. We have graduate assistants and adjunct faculty teaching. We've had conditions where courses have been canceled. All of these indicate that the quality of engineering education has been greatly diminished in recent times in the past few years because of this great overburdening of the engineering educational system.

At the present time we have about 18,000 engineering education teaching positions and about 1,600 of these are open, unable to be filled. That does not restore us to the 19—about 10 years ago—the late 1960's student-faculty ratios. If we were to do that we would need about 23,000 faculty members, or 5,000 additional positions.

So we believe that the Federal initiative should leverage private sector and other non-Federal support to help the engineer schools sustain themselves.

We particularly think an example such as the title II of H.R. 1310 are essential-type programs and we urge that this type of program be included in your actions.

The problems that exists right now are: 80 percent of the engineering colleges are limiting enrollment, they raised the admissions standards, eliminated transfers from other disciplines and other colleges, and established numerical cutoff points for size of entering classes.

We're very concerned about the effects this has on minorities. We in engineering education have made great efforts to increase the number of minorities and the number of women entering engineering education. We are concerned about the limiting of enrollments effect upon minorities.

We also have a second part affecting quality. That is the deteriorating instructional equipment and facilities. An NSPE study indicated that the average lab inventory has dropped from $5.8 million in 1971 to about $0.9 million for each individual school. We have lost great ground in the last 10 years. Based on some 250 schools, the need right now is for $1.2 billion. I would like, for the record, to have that corrected because the statement indicates $1.2 million.

Senator HATCH. Without objection.

Dr. HOGAN. It should be $1.2 billion and that's for 1971. We look at 1981 enrollments and we have a $2.2 million program. This sounds like a pretty horrendous problem, and it is, but I point out that it's about $400 per full time equivalent school student per year, or about $2,000 per B.S. degree award.

We do support cooperative ventures. As I pointed out on the faculty shortage project, we've had 11 industries sponsor this. On our minorities efforts we've had great participation on behalf of the government and industry, and other sectors.

We do strongly support your precollege efforts and again urge that something such as title II of H.R. 1310 be included.

We've had great pride in our graduates. They have put a man on the Moon and brought us into the computer age. We're losing that pride as we worry about the quality of what we are doing. We would appreciate your help.

Thank you.

[The prepared statement of Dr. Hogan follows:]

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

STATEMENT OF THE

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

AND THE

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

ON

MATHEMATICS AND SCIENCE EDUCATION

TO THE

COMMITTEE ON LABOR AND HUMAN RESOURCES

UNITED STATES SENATE

April 18, 1983

Mr. Chairman, Members of the Committee, I appreciate having the opportunity to comment on math and science education. I am Joseph C. Hogan, Dean Emeritus of Engineering at Notre Dame University. I am here on behalf of the National Society of Professional Engineers (NSPE) and the American Society for Engineering Education (ASEE), which I currently serve as President. NSPE represents over 80,000 members nationwide, including engineers in government, private practice, industry and construction as well as in education. The education division includes over 3,000 engineering faculty and deans from all engineering disciplines.

ASEE has an individual membership of approximately 10,000 primarily engineering college and faculty members, plus an institutional membership composed of the engineering colleges of the nation, a large fraction of the major corporations which are the prime employers of engineers, government agencies which are heavy users of engineering manpower, and the major engineering professional societies.

We in the engineering education community share your concern about the current state of precollege mathematics and science education. While we commend the Committee for developing legislation to solve those problems, we are greatly concerned that in the current rush to address precollege issues, the related and equally critical problems facing engineering education may be overlooked. If the nation is to truly improve its scientific and technological capabilities, we must look at the full education spectrum, not just the opening to the pipeline.

Engineering is the application of scientific, mathematical and technical knowledge. The current well-documented crisis in engineering education is clearly limiting the ability of our colleges and universities to provide our future engineers with a quality education. In today's climate of rapidly growing technical sophistication and increasing competition for world technology markets, we simply cannot afford to produce engineers at less than the optimum quality and quantity level demanded by the United States' position of world technological leadership. As a nation, we must recognize and address the severity of the engineering faculty shortage*, the extent of obsolete and inadequate instructional engineering equipment as well as the shortage of secondary school math and science teachers. Improving the mathematics and science literacy of our youth will have limited impact on the economy unless we focus on the entire problem.

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*President Reagan at EPCOT on March 8, 1983.

Before turning to the Committee's bill, S.706, I would like to describe, in detail, the engineering education problems referred to above. The two most fundamental weaknesses in the system are a critical faculty shortage and ill-equipped laboratories and facilities. Limitations on these essential resources have major and adverse effects on the quality of education schools can provide.

To better define the problem and develop solutions, ASEE, the American Association of Engineering Societies and eleven major corporations have sponsored the Engineering College Faculty Shortage Project (ECFSP). ECFSP data indicate that there is indeed a critical shortage which needs immediate attention. The vacancy rate for the entry level assistant engineering professor is approaching 25 percent, with 56 percent of those openings having remained unfilled for more than one year. A typical university has not received one application for a qualified U.S. citizen during a recent three-month search period.

These unfilled positions are certainly cause for alarm but they do not begin to describe the condition of overload of engineering college faculty members. An ECFSP survey based on data tabulated in the fall of 1981 and reported out in November 1982 showed that 120 schools (about one half of those in the United States with accredited programs in engineering) responded that it was clear that teaching loads had increased dramatically.

For example, 71 percent of the deans reported that their schools had been affected by the need to increase teaching loads on the existing faculty. Furthermore, 32.5 percent reported a measurable reduction in faculty research -- a key ingredient in keeping faculty au courant. In addition, 72 percent said the faculty was placing greater reliance on graduate teaching assistants or part-time faculty. It must be pointed out that with graduate school enrollments at an all-time low, there are precious few graduate teaching assistants to draw upon for support. This directly affects the grading of homework and examinations and laboratory course supervision and is a major contributor to the recently reported* decrease in quality of engineering education. Perhaps even more significant is the fact that 48 percent reported cancellation of cataloged courses in certain subjects pertaining to engineering education. This could mean students are deprived, in some instances, of basic courses and certain electives which have been offered in the past. All four of these issues document a critical situation relating to faculty overload.

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*11/7/82: "The Quality of Engineering Education", NASULGC

One of the most clear indications is the relationship of numbers of students to faculty. As the attached graph shows, faculty size has not increased anywhere near the rate of enrollment growth over the last decade. Reducing the current student/faculty ratio to that of the late 1960's (a time of full workload and quality instruction) shows that the number of faculty positions required for a teaching load consistent with that of the 1968-69 academic year is not the 18,000 now available but 23,092. Therefore, an additional 5,092 engineering faculty members are needed now to provide quality education.

In a ten percent sample survey late last fall, 28 deans responded that 77 percent of their schools were using part-time teachers to alleviate the overload; 68 percent were using adjunct faculty from industry, government and other sources, and 63 percent were using foreign nationals who may have limited abilities in the classroom.

While these interim measures are both necessary and useful, they will not solve the problem of recruiting and retaining qualified engineering faculty over the long term. Federal initiatives which leverage private sector and other non-Federal support would greatly enhance the ability of engineering schools to sustain themselves. Programs such as Title II of the recently passed H.R.1310 are essential. I sincerely urge the Committee to include such a program in its legislation.

One of greatest concerns over the Committee's approach to focus primarily on precollege education relates to enrollments. If, as we all hope, young people are to become more excited and knowledgeable about science, engineering and technology, it is reasonable to assume the demand for an engineering education will grow. This is particularly likely since while the demand for engineering graduates does fluctuate, it will surely remain high in the future as we seek solutions to major societal problems, all of which have an increasingly large technological component.

Engineering schools simply do not have the resources to accommodate greater numbers of students, nor will they in the future unless substantial steps are taken now. Referring again to the attached graph, with an 111 percent growth in enrollments over the last decade, engineering faculty has increased only 11 percent.I have already described the resulting problems. Data indicate that over 80 percent of the nation's engineering schools are limiting enrollments in an attempt to balance resources with students. Just two weeks ago this issue was considered at the 20th Annual Deans Institute of the ASEE. When over 140 deans from a cross-section of schools and locations were asked the question of whether enrollments were being curtailed in some fashion, nearly every hand in the room went up. The following measures are being adopted to either hold constant or reduce enrollments:

- raise admissions standard for entering freshmen
- eliminate admissions by transfer from other discplines and other institutions
- establish numerical cut-off point for size of entering class

Already many qualified youngsters are being turned away. A recent report on the quality of engineering education issued by the National Association of State Universities and Land Grand Colleges (NASULC) recommended that "Each school should realistically assess its resource base, and the enrollment level which that base can sustain in producing a high quality educational experience. Schools should make every effort to keep enrollments and resources in balance."

Instructional equipment and facilities are inadequate, both in terms of number and function. Comments by the Accreditation Board for Engineering and Technology (ABET) officials indicate that nearly half of accreditation actions in recent years can be traced to the deteriorating condition of engineering laboratories.

A study conducted last fall by the National Society of Professional Engineers reveals that the average laboratory equipment inventory per school declined from $5.8 million to less than $0.9 million during the period 1971-81. Based on 250 schools with one or more accredited programs, this leads to the conclusion that the cost of modernizing engineering laboratories (at the 1971 level of enrollment) will cost $1.2 million. If one considers the difference in enrollments of Full Time Equivalent (FTE) students between 1981 and 1971 this figure increases to $2.2 million.

Considering the life span of 10 years used in this study, expenditures per school for laboratory equipment should have been at the level of about $600,000 annually. Actual expenditures during the decade averaged $153,000 per school per year.

While this $2.2 million shortfall appears on the surface to be a staggering sum, an expenditure for laboratory equipment of about $400/FTE student annually or of $2,000/BS degree awarded could have prevented this decline in laboratory quality. The investment required to bring engineering indstructional laboratories up to date with state-of-the-art equipment should become a prime national priority. The Federal Government should both provide leadership and serve as a catalyst to generate non-Federal resources through matching grants administered in the National Science Foundation and through appropriate tax mechanisms.

With regard to the Committee's proposed legislation, I recognize and appreciate the importance of the initiatives you have proposed for precollege education. The need is so great, however, that I respectfully suggest that (1) it does not go far enough -- $250 million may be spread to thin to have a substantial impact and (2) the ability to leverage private sector and state support is not fully utilized. I do understand that the Committee is considering a cooperative program between private sector, local educational agencies, states and schools, and I strongly support such a program. The engineering community would welcome the opportunity to participate in precollege education programs.

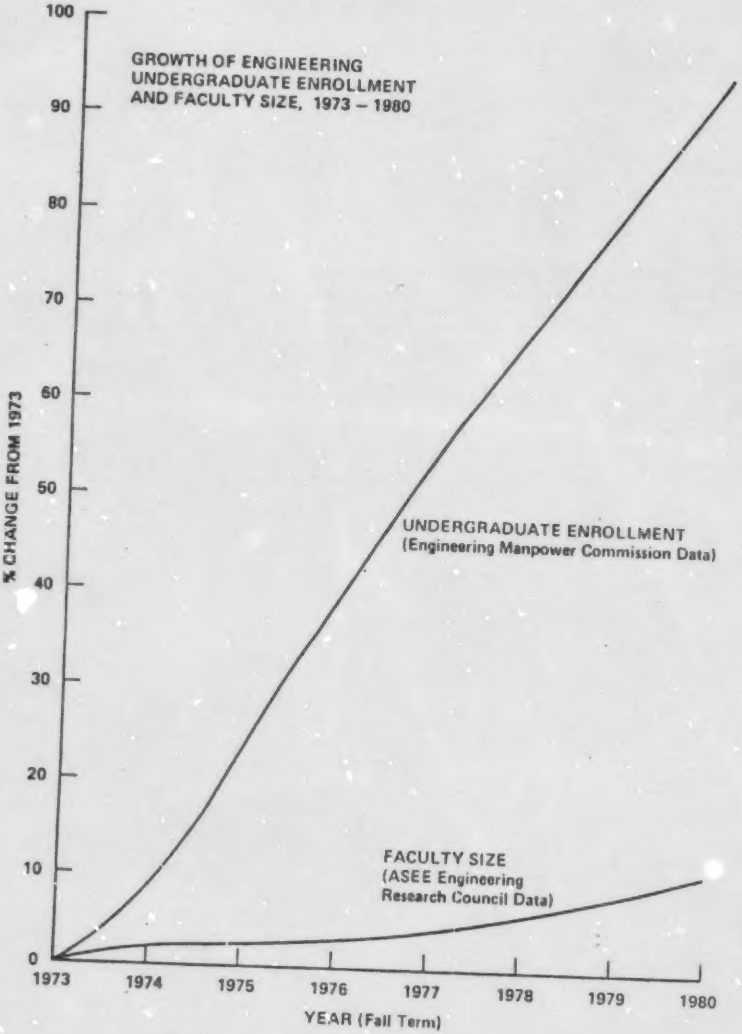
For example, engineers have been involved in a Texas Instruments program of math motivation for remedial students in Texas schools systems. Over 100 industry employees are sharing their enthusiasm for math, technology and science with young people through the program. Those who work directly with science, technology and math -- engineers -- are often able to make these subjects relevant and exciting for otherwise unmotivated young people.

The Junior Engineering Technical Society (JETS) programs (over 425 engineering, technology and science clubs in 34 states at high schools with over 8,500 student members) now 33 years old, serve to draw attention to the national need. Cooperative programs initiated at the Federal level can serve the important function of generating community-based partnerships between education, government and industry that are essential to long term solutions of the problems we are discussing here today.

In summary, I would like to comment the Committee for the fine efforts you are making to address the problems of inadequate math and science education, and reiterate the importance of including a matching grant program for engineering faculty recruitment and retention, and instructional equipment. Title II of H.R.1310 serves as an excellent example.

Thank you very much. I will be pleased to respond to any questions. I would also like to share with you a document developed cooperatively by the education and engineering communities which more precisely defines the elements we believe are essential to effective legislation in this area, many of which are included in your bill.

FIGURE 1



WEL/ASEE 8/82

ESSENTIAL ELEMENTS OF SCIENCE, MATH AND ENGINEERING EDUCATION LEGISLATION

-- A consensus view

The currently acknowledged crisis in engineering, mathematics, science, and technology related education is a threat to our economic productivity and military security. If we are to maintain our position in the international arena, then we must begin to take positive steps to reverse this decline in scientific and engineering learning and education.

The 98th Congress has an important opportunity for such positive actions. Recently the House, overwhelmingly and by a bipartisan vote, approved H.R. 1310, Emergency Mathematics and Science Education Assistance Act. We applaud this move as a positive first step in addressing the current educational crisis. The Senate will soon begin to consider numerous legislative proposals of its own in this important area.

A broad group of organizations representing diverse elementary, secondary and higher education as well as private sector constituencies have been meeting over the last few months to consider the appropriate roles of the Federal government and the private sector in meeting the pressing problems in math, science and engineering education. In our view, it is clear that the components outlined below are essential to an effective legislative solution to these problems.

At the National Science Foundation we urge the establishment of programs to:

. expand engineering and physical science fellowships, traineeships, research incentive awards and faculty awards for summer study.

. upgrade undergraduate instructional equipment and its utilization;
. upgrade and improve instructional programs and materials, in engineering, mathematics, science and technology at all levels; and
. leverage state and private sector resources through matching grants to achieve these purposes.

At the Department of Education we endorse programs to:

. retrain precollege teachers in effective instructional skills and substantive knowledge;
. support summer institutes and workshops for teacher training initiatives aimed at improving mathematics, science and technology education;
. strengthen and improve the contributions of education research and development; and
. provide student assistance to attract qualified persons to be mathematics and science teachers.

We urge the Senate to adopt legislation that will contain these elements. In this way positive first steps will be taken to reverse the serious decline that is currently threatening our economic and military security. We recognize the necessity for immediate action to deal with the most critical problems and acknowledge that more long range and comprehensive solutions will be necessary. We feel that the elements proposed above can be funded for less than $500 million, which is consistent with the reality of current budgetary conditions, and will provide an important step toward long-term solution of the critical problems currently facing math, science and engineering education.

Attached is a list of the organizations that endorse the principles outlined.

AMERICAN ASSOCIATION OF COLLEGES FOR TEACHER EDUCATION

AMERICAN ASSOCIATION OF COMMUNITY AND JUNIOR COLLEGES

AMERICAN ASSOCIATION OF SCHOOL ADMINISTRATORS

AMERICAN ASSOCIATION OF STATE COLLEGES AND UNIVERSITIES

AMERICAN ASSOCIATION OF UNIVERSITY PROFESSORS

AMERICAN COUNCIL ON EDUCATION

AMERICAN EDUCATIONAL RESEARCH ASSOCIATION

AMERICAN FEDERATION OF TEACHERS

AMERICAN PERSONNEL AND GUIDANCE ASSOCIATION

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

COUNCIL OF CHIEF STATE SCHOOL OFFICERS

COUNCIL OF GRADUATE SCHOOLS IN THE UNITED STATES

COUNCIL OF GREAT CITY SCHOOLS

INTERNATIONAL READING ASSOCIATION

NATIONAL ASSOCIATION OF ELEMENTARY SCHOOL PRINCIPALS

NATIONAL ASSOCIATION OF INDEPENDENT COLLEGES AND UNIVERSITIES

NATIONAL ASSOCIATION OF STATE BOARDS OF EDUCATION

NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES

NATIONAL CONGRESS OF PARENTS AND TEACHERS - NATIONAL PTA

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

NATIONAL EDUCATION ASSOCIATION

NATIONAL SCHOOL BOARDS ASSOCIATION

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

NEW YORK STATE EDUCATION DEPARTMENT

STATE OF WASHINGTON DEPARTMENT OF EDUCATION

Senator HATCH. Thank you, Dr. Hogan.
Dr. Parry.

STATEMENT OF DR. ROBERT W. PARRY, DISTINGUISHED PROFESSOR OF CHEMISTRY, UNIVERSITY OF UTAH, SALT LAKE CITY, UTAH

Dr. PARRY. Senator Hatch, because of your time constraints I'll abstract my statement.

Thank you for this opportunity to present the views of the American Chemical Society on science and mathematics education. This is a complex and important topic as you are well aware. Since June of last year, the National Science Board Committee on Precollege Education in Mathematics and Science has been reviewing the issues involved. My participation as a member of that Commission has convinced me of the complexity of the problem and of the need to offer support to teachers. Quality precollege education is now available at some places in the United States. We are not educationally bankrupt, as Mrs. Mitchell noted. The task before us today is to make quality education available to all. I and many of my colleagues in the American Chemical Society are convinced that well trained, strongly motivated, dedicated teachers, freed from deadening administrative routine, will play a major role in future educational success. The comments of Mr. Louis Goffredi add support for this premise.

Because the precollege education problems have reached crisis proportions nationwide, a strong Federal initiative is needed today. The American Chemical Society supports immediate action by the Federal Government as an emergency measure, but we are even more concerned with the development of a long-range, focused Federal policy that will make emergency legislation unnecessary in the future. We are convinced that central to this policy must be a firm commitment by society to make the teaching profession more attractive, both in terms of remuneration and social prestige.

Because of time constraints, my oral presentation today will focus on precollege education, but our written testimony also covers some aspects of the very important undergraduate and graduate programs in our Nations colleges and universities. These critical areas must not be forgotten in our concern over precollege programs. Here is a very brief summary of our views on precollege education.

The American Chemical Society believes that the very first Federal priority at this time should be to help current science and mathematics teachers in secondary schools upgrade their subject matter competence. We believe that this is best accomplished through summer and inservice institutes comparable to the very successful institutes sponsored earlier by the National Science Foundation. As the statement of Mr. John Thayer indicated this morning, there is a widespread feeling in both the educational and scientific communities that these NSF institutes ranked among the most successful in the Nations' educational efforts.

We believe that similar institutes should be established immediately and that responsibility for all phases of administration should be assigned to the NSF. In our judgment, this agency is uniquely qualified to unite educators with professional research scientists. Cooperation of educational professionals and professionals in science and mathematics is absolutely essential to the success of future programs.

We recommend that the Department of Education should assume the responsibility for inservice programs in local education agencies, particularly for those very important programs associated with primary and junior high schools. The subject matter for such institutes should be developed jointly by teachers, professionals in science and mathematics, and by the local institutions which they represent. Because of existing ties between LEA's and the Department of Education, the Department is best qualified to administer these programs

The ACS places highest priority on the retraining of current teachers and upon efforts to improve the image of the profession. We believe, therefore, that funds should not be made available to support awards for teaching excellence or for the training of future teachers until ample provisions are made for the training of existing teachers and for a careful review and upgrading of curricula as needed. Mr. Clinton Brown highlighted problems of selection of award recipients.

The Society recommends that the scholarships proposed by the administration should go first to teachers already teaching in science and mathematics so that they may improve their professional skills and become more directly involved in the ongoing research and education in the discipline. The next category of recipients should be those people who have disciplinary expertise, but who are not certified to teach. We do not believe that a scholarship program for future teachers represents an optimal use of funds at this time. First, the level of funding now under consideration does not appear to be adequate to support both the training of existing teachers and the training of new teachers. We are convinced that efforts to upgrade the profession of teaching will do more to attract top quality new teachers than will scholarship help for those already in college. Further, it is not clear that a good mechanism now exists to insure that scholarship recipients will commit themselves enthusiastically to teaching careers.

A review of existing curricula and the development of new curricula, as needed, should be carried out through NSF programs. On the other hand, funds to purchase finished products should be made available to local educational agencies through the Department of Education. We further believe that the Department should administer any block or formula grants which are to be created.

We are aware that the committee is interested in the development of consortia to attack educational problems. We endorse such an approach. However, we believe that matching fund requirements, proposed in some versions of suggested legislation, should be limited to addressing second-line problems. For example, it would be unwise to count on large sums of money from the private sector as a requirement for programs to upgrade the subject matter competence of many of todays teachers. This is a public responsibility. If legislation authorizing consortia is put in place, we urge that professional societies be included in the list of bodies eligible to participate. Our members have much to offer.

Because of our interest in the involvement of industry in aid to education, we recently canvassed the top 50 chemical producers in the country. We are encouraged with the results. The current attitude of company officials strongly suggests that industry will respond positively to requests for more help. However, the extent of contributions, either financial or inkind, will depend greatly on the pace of economic recovery. At best, contributions will be small in relation to the size of the problem ahead. A large Federal commitment is necessary.

The American Chemical Society notes that there is a contribution to be made by the NSF and the Department of Education. Both agencies bring special expertise to the problems facing us. The society recommends that a coordination function be established in the Office of Science and Technology Policy. Annual reports of this office to the President and the Congress would then include a section on the coordination of Federal activities in science and mathematics education, and the divisions of responsibility could be objectively reviewed.

Finally, the ACS has a number of activities aimed at supporting precollege teachers. We are happy to cooperate with todays teachers in providing support through many programs. The American Chemical Society is currently marshaling the human resources of the American chemical industry in an effort to assuage todays problems in science education. In our judgment technical skills can be more important than money. A new ACS program operates on this premise.

Thank you, Mr. Chairman. I will be happy to respond to any questions which you or members of the committee would care to direct to me.

[The prepared statement of Dr. Parry and responses to questions asked follows:]

TESTIMONY OF

THE AMERICAN CHEMICAL SOCIETY

Presented by

DR. ROBERT W. PARRY
PAST PRESIDENT

Before the

COMMITTEE ON LABOR AND HUMAN RESOURCES
UNITED STATES SENATE

HEARINGS ON SCIENCE AND MATHEMATICS EDUCATION

Monday, April 18, 1983

Introduction

Mr. Chairman and members of the Committee on Labor and Human Resources, the American Chemical Society (ACS) welcomes this opportunity to present its views on science and mathematics education. The Society is a congressionally chartered non-profit scientific and educational association with a membership of more than 127,000 chemists and chemical engineers. Our membership includes educators and researchers at colleges and universities, scientists and engineers in government and industry, and some high school teachers and administrators.

Current attempts to develop legislative remedies for the shortage of adequately trained science and math teachers at the precollege level and the shortage of certain teaching resources are complex processes taking into consideration a great number of factors. As a result, a great number of bills have been introduced in the Senate. Our understanding is that there are now two major measures before your committee. One is associated with Senator Stafford and the Subcommittee on Education, Arts and Humanities which he chairs. Mr. Chairman, we understand you are introducing the other bill on April 15.

In the Stafford bill, which is a revised version of S.530, almost all programs require matching funds. A broad array of activities can be funded with the $400 million in the bill, and for a state to receive any of this money, it must submit what are essentially plans for raising matching funds and spending the aggregate funds. In contrast, we understand the approach in Senator Hatch's bill is to target the smaller sums authorized by limiting the activities that can be supported.

Given this situation, it is the view of the American Chemical Society that we can best help by setting forth in this testimony what we believe to be the necessary elements of a comprehensive federal effort in science and mathematics education. In addition, the Society has developed general comments based upon what we know of the provisions contained in the two major bills being considered in your committee. We intend to supplement this testimony with specific comments after we have an opportunity to review the texts of these bills.

This testimony will also highlight the role the American Chemical Society has been playing in chemistry education. We have greatly increased our efforts in this area in the past five years, partly in response to the tremendous need for support expressed by precollege chemistry and physical science teachers throughout the country. The activities of the chemical industry in this area will also be reviewed.

The Society is convinced that the current nationwide situation in the teaching of science and mathematics to precollege students has reached crisis proportions, and that a strong federal initiative is needed. Not only are more science and mathematics teachers needed, but there is also a need for improving quality--both in teaching and in the learning experience in our schools. The federal role should be to create the climate and provide the critical resources for initiating a sustained long-term national commitment to bring quality science and mathematics instruction to all the young people of this country. This instruction is essential if the nation is to meet its future manpower demands, and if our young people are to find meaningful employment in our increasingly technological society.

While the Society supports immediate action to address the many problems in precollege science and mathematics education, we must stress the importance of developing a long-range, focused federal policy that will make emergency legislation, such as the many initiatives now before the Senate, unnecessary in the future. This country has faced a crisis in science and mathematics education before, and we will do so again and again unless, this time, long-term solutions to the problems facing us today are implemented. For example, the teaching profession at the precollege level needs to be made more attractive than it is now, both in terms of remuneration and social prestige. This is a fundamental problem not being addressed in the current debate.

Roles of Governments and Other Institutions in Science and Mathematics Education

The Society has developed the following fifteen principles concerning the involvement of governments and other institutions in science, mathematics, and engineering education from the precollege through post-graduate years.

1. The federal government should play a major role in: (a) precollege education; (b) higher education including graduate research; and (c) educational research, analysis, and information brokering.

2. There is a contribution to be made both by the National Science Foundation and the Department of Education. The resources of both agencies should be fully utilized to mount a concerted and coordinated effort to solve the current problems in science and mathematics education. The Society recommends that a coordination function be established

at the federal level. It should reside in the Office of Science and Technology Policy, and the annual reports on science and technology policy to the President and the Congress should include a section on the coordination of federal activities in science and mathematics education.

3. Cooperative programming efforts should be fostered to the greatest extent possible among the National Science Foundation, the Department of Education, local and state educational bodies, colleges and universities, business and industry, professional associations, non-profit community organizations, and parents. The Society is especially concerned that mechanisms be established to ensure that research scientists from academe and industry work together with the education community in full partnership.

   The Society strongly endorses the establishment of state commissions on excellence in mathematics and science education. These are important mechanisms for establishing working partnerships between scientists, mathematicians, and educators at the state level. Such commissions are particularly needed in legislative schemes which allow states to determine how formula funds are to be used. Commissions must be given a significant role in these decisions. Scientists and mathematicians engaged in research and education, and precollege science and mathematics teachers should have seats on such commissions. Conferences of state commissions should be held periodically to exchange information.

4. At the precollege level, the federal role should be to provide funds to allow current teachers to upgrade their subject matter competence; help ensure that new teachers' subject matter knowledge meets the standards

necessary for certification in each state for full-time teachers in the particular subject; and sponsor the development of instructional materials relevant to the needs of all students. Subject matter specialists should assume a major role and responsibility for: (a) educational programs at the federal, state, and local levels to provide for professional growth of science teachers; and (b) development of science and mathematics curricula.

5. While the Society supports upgrading the subject matter knowledge of science and mathematics teachers to the highest current standards established in each state for certification, in many states the subject matter competence required for such certification is deplorably low. Therefore, the Society recommends that states be encouraged to raise their certification requirements for both full-time and part-time science and mathematics teachers. A number of scientific and mathematical societies, including the ACS, have published guidelines for the training and continuing education of precollege science and mathematics teachers. The level of subject matter competence recommended by these societies should be the minimum standard required of teachers.

6. Federal support should be provided to help colleges and universities update and replace obsolete instrumentation for both research and instructional purposes. The need for assistance with instrumentation purchases is especially critical for the two- and four-year colleges, many of which are now unable to provide students with the "hands-on" experience necessary to their training as future teachers and/or scientists. The National Science Foundation should provide such assistance to two- and four-year colleges.

7. Federal support should also be available to help colleges and universities keep their curricula and faculty up-to-date. At present, few faculty are able to find the time for either improving their curricula, or for personal professional growth. The availability of federal grants combining both research and instructional components would make it easier for faculty to devote more time to improving instructional quality at the college level.

8. Federal support of post-secondary education should include special funding to support undergraduate research in science and mathematics at public and private four-year institutions, as well as at the Ph.D.-granting universities. Undergraduate institutions have played critical roles in our national science effort. Between 1920 and 1980, 45% of the doctorate degrees awarded in chemistry went to persons who obtained their baccalaureate degrees from four-year institutions. Further, 32% of graduate chemistry faculty members earned their first degrees at four-year institutions. A drop in the number of good students entering graduate schools seems inevitable if funds are not made available to support programs at undergraduate colleges.

9. External review panels composed of knowledgeable scientists and mathematicians should be convened regularly to assess programs at both the precollege and college levels, and to recommend their modification, continuation, or termination as appropriate.

10. The federal government should develop programs that include incentives for a local commitment to solving problems in science and mathematics education. For instance, requiring that certain federal funds be matched by non-federal funds will necessarily bring into play more institutions at the state and local levels. The general public, especially parents, as well as public and private institutions at both the state and local levels must all be included in any campaign to improve the quality of precollege education in science and mathematics. This is especially important if society is to fashion long-term strategies for the support of science and mathematics education.

11. The resources of scientific and mathematical societies should not be overlooked. These organizations, including the ACS, constitute an enormous pool of talents and expertise that should be tapped for curriculum development projects, for upgrading the education of precollege science and mathematics teachers, for general assistance in providing quality education programs, and for programs to increase the participation of women and minorities in scientific and technological careers. Most of these societies have education divisions that would welcome the opportunity to help solve our current problems in science and mathematics education. Many also have local units that would be willing to assist school authorities in developing in-service teacher training programs, or provide assistance in other activities.

12. Any federal program that distributes funds to states on a formula basis should permit the greatest possible flexibility in the allocation of funds within each state. Given current financial resources, however,

these monies should be targeted to specific types of programs. For example, at the precollege level the first priority should be to retrain currently-employed science and mathematics teachers to meet state standards required for full-time certification in their intended subjects. States should not fund programs that could better be carried out by awarding one-time competitive grants through the NSF. For example, up-to-date information about available computer software in any mathematics or science discipline concerns all 50 states, but this information should not be generated through 50 duplicate studies.

13. For programs to be successful and cost-effective, the federal government should take a more active role as an information broker and ensure wide dissemination of the results of projects, especially to teachers preparing proposals for support of related efforts. This would help prevent duplicative efforts at the local level. In the past, results--both positive and negative--of science education projects have not been widely shared. This has led not only to a tendency to "reinvent the wheel," but also to a misunderstanding of the effectiveness of many of the most successful science education programs funded in the past from federal resources.

14. Federal support should be given to programs aimed at increasing the participation of women, minorities, and other groups traditionally underrepresented in scientific and technological careers. These programs are necessary to ensure the full utilization of human resources in our nation's scientific and technological enterprises.

15. Any renewed federal commitment to improve science and mathematics education should include programs aimed at improving recognition, appreciation, and understanding of science and technology by the general public. These programs hold the promise of raising the level of technical literacy of the out-of-school population; they can stimulate the citizenry to care more about the science and mathematics education of their children. Popularized science and technology can also excite and capture the interest of the youngest of our citizens.

Division of Responsibilities Between NSF and DOEd

The Society strongly recommends that the National Science Foundation play an important role in helping to solve the nation's current problems in science and mathematics education. The NSF has the staff, the organization, and the necessary experience in successful programming to be responsible for administering all federal competitive grants intended to:

- Upgrade the subject matter knowledge of secondary school teachers of science and mathematics;
- Encourage students to enter careers in mathematics and science teaching;
- Conduct teaching and learning research into effective methods of instruction in science, mathematics, and the use of computers;
- Upgrade science and mathematics curricula in secondary schools and at the college level; and

- Support post-secondary science and mathematics education.

It is vital that subject matter specialists be given the major responsibility for developing these programs. These specialists historically have had close connections with the Foundation. Further, the well-established peer review mechanism in place at NSF will ensure that only the highest quality, most cost-effective programs will be funded.

The Department of Education, on the other hand, has been responsible for elementary mathematics and science education, and has the same kind of close linkages with state and local governments that NSF has with institutions of higher learning. The importance of the role of the Department of Education in promoting more and better science and mathematics at the elementary level cannot be overemphasized. Effective elementary science instruction is vital since it is during those formative years that life-long attitudes regarding science and mathematics are established. The Department should, therefore, continue to administer programs at this level. It should also administer any block or formula grants that are created as part of a federal initiative to improve science and mathematics education.

Comments On Legislative Proposals Under Consideration By The Committee

Retraining and Upgrading the Subject Matter Knowledge of Currently Employed Teachers

The ACS considers retraining teachers and upgrading their subject matter knowledge to be very high priority uses of federal funds. Regardless of the approach finally adopted, the goal of any legislation on science and mathematics education should be to help teachers meet state standards required of full-time teachers in science and mathematics.

Workshops and summer institutes, as well as continuing education courses in institutions of higher education, are preferred ways of achieving retraining and upgrading. The requirement that academic credit be obtained is a reasonable one.

The ACS recommends that the National Science Foundation be responsible for all phases (including content development, course delivery, and teacher stipends) of workshops and summer institutes designed to upgrade the subject matter knowledge of science and mathematics teachers at the secondary level. The Foundation has successfully operated summer institutes in the past; it is trusted and respected by the science and mathematics departments which operate these institutes; and the Foundation has a well-established and impartial system of peer review accepted by the scientific and mathematics communities. The Society recommends that such training activities be carried out in a coordinated manner between academic and education departments in colleges and universities.

The responsibility for improving the quality of teaching of science and mathematics in elementary schools should rest solely with the Department of Education. Any provisions concerning elementary education should also allow for the involvement of the scientific and mathematics communities.

The Department of Education should fund the operation of in-service programs in the Local Educational Agencies (LEAs). LEAs should undertake the development of materials and program content only in cooperation with professional scientists and mathematicians and the local institutions that employ them. In-service programs may or may not count toward degree credit, depending on the nature and length of the sessions.

Development of Materials and Curricula

The Society believes that the NSF should be the federal agency responsible for the development of materials and curricula for the teaching of chemistry, physics, biology, mathematics, and computer science in secondary schools. It is important for efficiency and cost-effectiveness that activities aimed at improving subject matter knowledge be funded at the federal level. Duplication can thus be avoided and wider distribution of products can be achieved.

The National Science Foundation, through competitive grants to individual organizations or consortia of institutions of higher education, professional societies, business, industry, and state and local school authorities, can produce the new tools that are needed to improve our science and mathematical educational system. The Society is dedicated to the idea that cooperation is essential between: (1) professionals in the disciplines of science and mathematics and in education, (2) professionals outside of the educational system, and (3) the public.

Funds to produce and market finished products to state and local educational agencies should be included in NSF grants, while funds for purchase of products should be made available to State Educational Agencies (SEAs) and LEAs through the Department of Education.

Scholarships For Future Teachers

At present, the ACS places a higher priority on a federal initiative for retraining current teachers than for training future teachers. First, the level of funding under consideration does not appear to be adequate to support both retraining of current teachers and training of new teachers. Second, a good mechanism does not exist for ensuring that scholarship recipients commit themselves wholeheartedly to teaching careers. Requiring scholarship recipients to teach for a number of years or else repay the scholarship money gives no assurance that teachers will teach with enthusiasm or remain in the teaching profession after the mandated period of service.

If a scholarship program is created, it is important that recipients be required to pursue an academic curriculum that would allow them to become certified as full-time teachers in the disciplines of science and mathematics. Public funds should not be used to educate the next generation of unqualified teachers who will require retraining later.

Scholarships for Present Teachers

As stated previously, the Society believes the first priority is to fund retraining and upgrading of those persons already teaching science and mathematics. Therefore, the Society recommends that the scholarships proposed by the Administration should go first to teachers already teaching science and mathematics, so that they may improve their skills and become fully certified. The next category receiving these scholarships should be those people who have disciplinary expertise but are not certified to teach.

Awards for Teaching Excellence

Funds should not be made available for awards for teaching excellence until ample provision has been made for retraining and other needs. If a program of awards is established, it should be made clear that recipients can use the award monies for any activity aimed at improving science and mathematics education in the schools. Teachers should be free to use these funds to pay tuition and expenses for attending workshops and courses that would improve their ability to teach precollege science and mathematics.

Distribution of Funds to SEAs and LEAs

The distribution of funds between SEAs and LEAs should depend on the overall level of funding authorized in the legislation, and by the array of programs that are feasible within that level of funding. It would appear unwise to distribute to each LEA such a small amount of funds that it is not likely to support any effective program.

Generally, the Society favors retaining at least 50% of funds at the state level. The need for focusing, targeting, and leveraging is even more pressing when only relatively small amounts of funds are available. The Society recommends that these factors be taken into account in the distribution of funds between states and localities.

Consortium Approach

The Society endorses the consortium approach which we understand is under consideration by this committee. The ACS recommends that the first priority under this funding approach should be to improve the capability of teachers, and enrich the learning experiences of children in elementary and secondary schools. Requiring joint applications for federal matching funds should promote the cooperation needed to attack the problem effectively. Any consortium should include, but not be limited to: state and local educational agencies; business and industry; institutions of higher education, including departments of education, sciences, and mathematics; professional societies; and other non-profit organizations.

The Society believes that in a consortium approach, funds should be awarded on a merit basis through the National Science Foundation. In the case of chemistry teaching, it would make the most sense for the National Science Foundation to administer consortium programs. First, the academic connection with NSF has a long history and is very strong. Second, the chemical industry's relationship with NSF has been improving over the last several years. Finally, the ACS's interactions with all three are very strong.

The NSF should be given the flexibility to determine what types of projects are eligible for funding, after consulting with representatives of sectors likely to participate in such programs, and after making an assessment of our overall national needs.

We have two notes of caution to add regarding the use of matching funds. This approach should be limited to addressing second-line problems. To put this type of program forward as the principal means of increasing the number of quality teachers or meeting other major needs would be unwise. A 50/50 matching approach should be limited to attempts to bring the community together to seek ways to improve upon and enhance the basic structure already in place. It would be unwise to count on large sums of money from the private sector to address problems that are fundamentally the responsibility of the public sector. As consortia move away from local projects toward more expensive projects addressing problems of a wider focus, then the private sector percentage of the match should decrease. Our second point is that consortia formation will not be possible in many school districts, such as in rural areas, across the country. Therefore, those that are likely to be most in need right now will not benefit from this type of program.

The Role of the ACS in Chemistry Education

The ACS has played and continues to play a major role in chemistry education at all levels. ACS efforts in chemistry education are carried out through various committees, its Division of Chemical Education, and its 179 local sections. This enormous volunteer effort is supported by a staff of 28 in the Society's Washington office.

Assessment of Chemistry Education

The Society has a major study underway to assess the current condition of chemistry education in this country, from kindergarten through the post-graduate level. While the Society has been moving boldly ahead in specific areas where it can make positive contributions, it is convinced that an overall assessment is necessary to understand the long-term requirements of the chemistry educational system. The study's objectives are to determine what the ACS needs to do to enhance chemistry education, and what other sectors of society need to do as well. When the study is completed this fall, we will let policy-makers know what ACS believes needs to be done to enhance chemistry education in the United States.

High School Chemistry Programs

The ACS commitment to the high school community goes back to 1922, and that commitment has been greatly enhanced over the past several years. An outstanding example is a new chemistry curriculum being developed by the Society for the general student at the 10th grade level. It is called "Chemistry in the Community," and provides an understanding of the chemistry involved in important public issues. The project is supported by NSF, the ACS Petroleum Research Fund, the ACS Committee on Chemical Education, and the ACS Corporation Associates, an industrial affiliate of 180 corporations in the chemical business. The actual curriculum development work is being done by prominent chemical educators in institutions of higher learning throughout the country working together with high school teachers.

An attachment to this testimony, "The ACS High School Program," details many of the other wide-ranging activities of the Society at the secondary level. Unquestionably, the Society's commitment is large, and that is why its membership is interested in having professional societies and practicing scientists specified explicitly as partners in any new legislative initiative.

Public Recognition, Appreciation and Understanding of Science and Technology

The ACS Office of Public Relations has several projects and programs underway that are aimed at public understanding, but also find uses in high school science education. Three ACS planetarium shows have been widely used in high schools, as has the film "Chemistry and Man." The "Man and Molecules" tape series from the ACS radio program, now in its 22nd year on the air, is used in the classroom as well.

The Office of Public Relations has organized a competition to select a chemistry experiment to be performed on a future space shuttle flight. Also, we recently produced a high school study course entitled, "DNA--Master Molecule of Life."

At our March 1983 National Meeting in Seattle, the Society sponsored an afternoon program for local chemistry teachers and students, as we have done at each national meeting. Approximately 1,000 attendees listened attentively as Nobel laureate Glenn Seaborg told of his fascinating discovery of new chemical elements. They also saw and heard an exciting educational chemistry magic show presented by Dr. Hubert Alyea.

ACS Local Sections' Programs

The 179 ACS local sections around the country have been particularly helpful within their own communities in establishing programs for high school teachers. The majority of local section members are from industry, and often receive support from their companies in organizing activities such as local workshops and seminars, tours, and career programs; providing classroom speakers; giving advice on safety issues; and offering scholarships to students. The level of activity at the local level has increased markedly over the past five years.

The ACS local sections' programs are too numerous and diverse to describe in detail. In short, these programs are nationwide, they receive some support from the chemical industry, and they have been extremely successful. Sometimes contact between a section and a school community has been initiated by the local section, sometimes by local educators, and sometimes by ACS staff. All successful programs typically have involved schools and a given local section in working partnerships, where both groups recognize the value of each other's experiences.

ACS Corporation Associates

Recently, the ACS Corporation Associates held a one-day conference in Washington entitled, "Using Industrial Chemists to Enrich Chemistry and Science Education." The educational, industrial, and scientific communities were all represented at this meeting, and freely exchanged information on currently existing programs, perceived needs, potential problems, and opportunities for future collaborative efforts.

While educators at this meeting expressed some reservations concerning business involvement in precollege science education, there was agreement that such involvement could be extremely helpful provided that business worked in close partnership with local education authorities. Since needs differ tremendously from one educational jurisdiction to the next, there were no global recommendations to industry to develop one particular type of program. Instead, numerous models for business involvement in the schools were discussed such as the "Science Consultants Program" of the Xerox Corporation, the "Chemical Caravan" and "Chemical Pilgrimage" organized by the Chemical Industry Council of New Jersey; and the "Program for Rochester to Interest Students in Science and Math" run by the Industrial Management Council of Rochester, New York.

As a result of the conference, Corporation Associates is supporting a six-month pilot project currently underway in Philadelphia. A local high school teacher on sabbatical leave is working on forging links between area high school teachers and people in local corporations to establish programs for the 1983-84 school year. Also, this teacher will prepare a directory of local industrial resources that high school chemistry teachers can draw upon for classroom enrichment or other purposes. Corporation Associates hopes to expand this project to additional cities next summer, using high school teachers on summer break.

Involvement of Industry in Chemistry Education

Even though industrial-academic ties traditionally have arisen through the use of academic scientists and engineers as consultants, or through industrial support of certain types of academic research, it is clear from the above description of ACS programs that chemical-producing companies have made significant contributions to precollege education projects nationwide. To gain a better understanding of the nature and scope of this industrial involvement, particularly those activities in which ACS did not serve as an intermediary, we recently canvassed the top 50 chemical producers in this country. So far, we have heard from 43 companies. Only one company representative indicated that there was no involvement, or plans for involvement, in precollege science education. Of the seven companies we have yet to reach, we are fairly certain that five have some activity in precollege education.

From these and other contacts with chemical-producing companies, it is very clear that these companies have demonstrated a significant interest and level of involvement in precollege science education. Three prevailing reasons seem to be: (1) corporate interest in community affairs, (2) interest in providing employees' children at company locations with good educational opportunities, and (3) concern about the supply and quality of potential employees. Company involvement runs from financial contributions to direct employee interaction with precollege students and teachers. Some companies initiate their own programs, while others participate through industry associations or through organizations such as the ACS.

Overall, chemical-producing companies are involved mostly through their individual operating units. As a result, the focus is at the local level. Only in a few instances are corporate projects intended to impact at the regional or national levels. The most common forms of participation seek to enrich the learning experience in schools. A few programs for upgrading the subject matter knowledge of teachers were reported. Support for materials development and equipment donations was less frequently reported.

It was not possible to determine from our review what the industry-wide dollar figure is for contributions to precollege education, either in terms of direct monetary support or in-kind contributions. Similarly, there is no catalog, either comprehensive or partial, of the individual activities supported by chemical producing-companies.

In an attempt to partly fill the void, the ACS, in cooperation with its Corporation Associates, will publish in early 1984 a compendium of model programs for industrial-academic cooperation at the precollege level. Models will be taken from existing company programs, and programs developed by associations, government, the educational community, and other sources.

Several proposals before this committee rest on the premise that industry will continue and even increase its involvement in precollege education in science and mathematics. The Society believes these proposals have some merit. However, we hasten to point out that, just as in the case of support of academic research, industrial contributions cannot be expected to assume more than a very minor role in the direct support of precollege education.

It is clear from our contacts with companies, and from the recent conference sponsored by Corporation Associates, that chemical producers are more likely to support programs where the expertise of industrial personnel is utilized in program development and implementation, rather than programs that require only financial contributions from industry. Participation in program development is also more likely to bring long-term commitment on the part of companies.

The questions before us are: What can we expect of industry's participation in the future? How will the availability of federal matching funds affect their decisions? At the moment, we do not know how chemical producers will respond to requests for more help. During our canvassing, we did try to assess company attitudes about more involvement. The current attitude of most company officials strongly suggests that industry will respond positively. However, it is clear that the response to any request for additional contributions will depend on the pace of economic recovery for the industry overall.

Thank you, Mr. Chairman and members of the Committee for this opportunity to present the views of the American Chemical Society on science and mathematics education in the United States. We offer the resources of the Society to the Committee and its staff for consultation, and would be pleased to answer any questions you may have.

The ACS High School Programs

History of Involvement

The ACS commitment to the high school community goes at least as far back as 1922 when the ACS Committee on Chemical Education, the precursor to the now Division of Chemical Education, developed a "Standard Minimum High School Course Outline." This outline curriculum remained in use until 1939 when it was revised and republished as an "Outline of Essentials for a Year of High School Chemistry."

Since then, the Division of Chemical Education, in particular, has been the focus of ACS high school-related programs. In 1924, the Journal of Chemical Education was first published; and in the early 1930's the Division began its testing program for high school and college students. Both the Journal and the testing program are still flourishing.

The early 1960's were notable for an emphasis on new approaches to introductory chemistry. Both the Chemical Bond Approach Project and Chem Study were initiated by members of the American Chemical Society, though they were not themselves Society programs. While Chem Study is now used in only about 11% of schools and CBA in maybe 1% to 2% of schools, the two projects have influenced an entire generation of chemistry textbooks.

The James Bryant Conant Award in High School Chemistry Teaching was established in 1965 by E.I. duPont de Nemours and Company, Inc. This ACS-administered award, now sponsored by the Ethyl Corporation, recognizes excellence in high school chemistry teaching and consists of $2,000 and a certificate presented at the annual ACS spring meeting. Teachers are nominated for this award through ACS local sections, many of which present their own awards to outstanding teachers within their own communities.

Over the years local sections around the country have conducted a variety of other programs to support the professional growth of high school teachers and to promote excellence in teaching, and learning, at the high school level. Activities have included various teacher workshops, student competitions, science fairs, classroom speakers, career counseling, safety programs, etc. Although not all local sections have conducted these types of program, many have, and they have rarely been publicly recognized for the excellent job they have been doing over the years.

New Initiatives in Programming

Clearly, the Society has an historical record of involvement with the high school community. It is true, however, in the past five years the commitment of the Society to high school chemistry teachers and teaching has expanded by a quantum leap.

The year 1977 was probably seminal in the expansion of ACS efforts in this area. In 1977, the Society published "Guidelines and Recommendations for the Preparation and Continuing Education of Secondary School Teachers of Chemistry." "Guidelines" not only contained the basic guidelines for pre-service and in-service education of high school chemistry teachers, it also contained recommendations for implementation of the various guidelines. These guidelines have recently been reissued and are available free to teachers and administrators.

Following this publication, the Society undertook major new initiatives toward the high schools on three fronts: first, the Society awarded a grant to the *Journal of Chemical Education* to support the development of a secondary school section and to employ a high school chemistry editor; secondly, in late 1978, the Division of Chemical Education established a High School Chemistry Committee, the majority of whose members are currently teaching high school chemistry; and, thirdly, in February 1979, the new staff Office of High School Chemistry was established.

The *Journal of Chemical Education* now publishes an average of 20 pages per monthly issue for high school teachers. Over the past three years high school teacher subscriptions to the *Journal* have increased by almost 500%. This truly astonishing increase surely attests to the value of the *Journal* to the high school teacher.

The ACS Division of Chemical Education (DIVCHED) High School Chemistry Committee has focused upon organizing symposia for high school teachers at national and regional meetings. Since the Einstein Centennial Program in Washington in the fall of 1979, almost 1,000 high school teachers have attended national and regional meetings at special guest admission rates. Programs presented have included topics such as safety, demonstrations, thermodynamics, bonding, electrochemistry, problem-solving, and the high school/college interface. Most importantly, these symposia have been organized *by* high school teachers *for* high school teachers with the majority of papers coming from the teachers themselves.

High school teachers have also taken important organizational roles in both the 1980 DIVCHED Biennial Conference held at Rochester, and the 1982 DIVCHED Conference held in Oklahoma last August. Incidentally, the 1983 ChemEd Conference for high school teachers (part of a sequence of conferences held biennially at the University of Waterloo in Canada) will be held at Butler University with support from DIVCHED, the ACS Society Committee on Education, and the Indiana Local Section. Once again, high school teachers have the major organizational responsibility for the conference.

The DIVCHED High School Chemistry Committee also is examining various mechanisms to deliver continuing education courses to high school teachers especially from the ACS Audio Course catalog. For example, for the past three years, teachers attending the New England Association of Chemistry Teachers Annual Meeting have been able to take an ACS Audio Course for academic credit. The Committee is encouraging local sections to develop similar activities for local teachers. They are also looking at ways in which the courses could be modified to make them more useful to the high school teacher.

The Office of High School Chemistry

The staff Office of High School Chemistry now administers four programs: High School Chemistry, a newsmagazine for high school students, Career Services, and Project SEED. The Office both initiates its own activities and serves as a liaison to other groups with high school chemistry programs both within the Society and without.

Most services of the Office are intended for any interested high school chemistry teacher, not just those who are currently members of ACS. For example, the high school newsletter, Chemunity, which is distributed free to about 7,300 teachers at present, provides teachers with information on past, present, and future pre-college activities of the Society. The number of teachers who receive this quarterly publication grows daily.

The Office also directs the Expert Demonstrator Training Activity (EDTA) workshops. These regional, two-day meetings, supported by the ACS local sections, are designed to (i) introduce high school teachers to the art and science of effective lecture-demonstration, and (ii) encourage increased interaction between local sections and high school teachers through the organization of local "multiplier" workshops.

To date five workshops have been held involving over 30 local sections and approximately 130 teachers. Incidentally, although the cost of the workshop comes from the ACS High School Office budget, the ACS local sections pay travel and per diem expenses for the teachers. The local sections also pay for the multiplier workshops which have introduced hundreds of other teachers to the EDTA experience.

The High School Film Library is restricted to ACS member-teachers (about 1,000 teachers at present). This Library was founded following a generous donation of films from Imperial Chemical Industries Americas, Inc., and has received additional support from ACS Corporation Associates and Phillips Petroleum. The library offers free-loan access to over 30 films and five Audio Courses.

The Office of High School Chemistry helps distribute the two most recent safety booklets produced by the Society to teachers. Free safety posters are also available from the Office upon request. The manager of the Office is currently working closely with members of the Council Committee on Chemical Safety to evaluate safety problems in the high schools and to identify possible mechanisms for addressing these problems. The manager is also in close liaison with the Consumer Product Safety Commission which is currently monitoring high school lab safety problems throughout the country.

With the demise of the ACS magazine, SciQuest, for financial reasons, the Office has taken over marketing the SciQuest poster and reprint program. Several new compilations of topics are planned for the future including a crossword puzzle book.

At the junior high school level, the Office has produced a curriculum-enrichment unit, Combatting the Hydra. The unit, which introduces science and society topics into the general or physical science classroom, has been reviewed by chemists and chemical educators throughout the country and has been teacher-tested in the classroom. "Hydra" covers the topics of food additives, use of fibers, pesticides, and energy. It includes a teacher's resource reader on these topics, teaching plans, ready-to-duplicate student activity sheets, bibliographies, and contact addresses for further information.

At the recent ACS national meeting held in Kansas City in September of 1982, the ACS Board of Directors voted to publish a newsmagazine, Chem Matters, for the high school student. This will be a quarterly publication containing feature articles, out-of-school chemistry experiments, safety tips, current events, games and puzzles, career information, pullouts, monographs, letters to the editor, etc. Two test issues of this publication are scheduled for field testing this spring with regular subscription issues becoming available by fall 1983.

One free copy of this new publication will be inserted in each Chemunity newsletter, beginning with the two test issues. Bulk orders of the publication will be available, at cost, through the ACS Office of High School Chemistry.

This new publication will be edited by a practicing high school chemistry teacher. Also, an editorial board, composed of a majority of high school chemistry teachers, is to be appointed to oversee the publication. The ACS Office of High School Chemistry serves as liaison to the editorial board and is responsible for production, marketing, and distribution.

The ACS is now conducting the nationwide search for the permanent editor. This editor will be responsible for supplying all final copy; making suggestions for artwork, illustrations, and photographs; and approving the final layout.

Career Services

The Career Services Program provides career guidance information to the high school student as well as to the undergraduate. New publications of the Program are focusing upon the importance of taking chemistry in high school, whether or not the student intends to study chemistry at university. In addition to providing information for the senior high school student, brochures are directed toward the middle school and, most recently, the Program has produced a booklet for elementary school students. Career Services staff assist local sections in the organization of career workshops in the high schools and are available to give expert talks whenever invited to do so.

The Career Services Program also administers the Society's participation in the annual International Science and Engineering Fair (ISEF) organized by Science Service. ACS sponsors ten awards -- four cash awards and six honorable mentions -- for outstanding projects in chemistry. The projects are evaluated, and the winners selected, by a team of judges from the ACS local section in which the Fair is being held. The 1982 ISEF was held in Houston in May.

Project SEED is a high school/career program of the Society that places economically disadvantaged high school students into summer employment in academic laboratories. Since its inception in 1968, Project SEED has placed over 1500 students into over 200 institutions for a 10-week work period each summer. Though the students receive a small stipend for their efforts, perhaps the most important part of the program for the students is the opportunity to develop a mentor relationship with their preceptors, and to receive career and college counseling from them. While the administrative costs of the program are borne by ACS, the student stipends come from voluntary contributions from individual ACS members, ACS local sections, industrial companies, and private foundations. In 1982, nearly 100 students received $750 each, with about $52,000 coming directly from the Project SEED stipend budget and the remaining funds contributed by the local sections.

This summer the Society received a grant of over $40,000 from the NSF under its Research Apprenticeships for Minority High School Students Program. Twenty students participated in the Apprenticeships Program with ACS matching student stipend monies with the Foundation.

Curriculum Development

Within the Department of Educational Services, the new Office of Program Development is administering another grant from the NSF. This grant for over $191,000 is to develop a new chemistry curriculum for the general student at the 10th grade level. The curriculum, CHEMISTRY IN THE COMMUNITY (CHEMCOM), is modular and will cover those areas of chemistry necessary to understand important chemistry issues of the day. It will also emphasize the importance and practice of decision-making skills related to interpretation of scientific data. Currently NSF is funding six of the modules with the ACS Petroleum Research Fund sponsoring one extra unit and ACS Corporation Associates supporting one other. Modules now being developed or planned include:

- Supplying Our Water Needs
- Feeding the World
- Petroleum: Its Uses, Reserves & Importance for Society
- Conserving Chemical Resources
- Alternative Sources of Energy
- Understanding Nuclear Issues
- Dealing with Chemical Wastes
- Chemicals, Air and Climate
- Chemistry in Public and Personal Health
- The Chemical Industry

The Office of Program Development is also administering a grant from NSF to develop at least six computer software packages to integrate with the first three modules of CHEMCOM. The SERAPHIM/CHEMCOM Interface Project (SCIP) integrates a chemistry software evaluation program being developed at Eastern Michigan University (and also funded by NSF) with CHEMCOM. The software will concentrate on developing decision-making skills in students through simulations and games.

Programs Throughout the Society

The expansion of ACS high school programs has been directed by the Society Committee on Chemical Education (and formerly by the Education Commission). The Pre-college and Non-professional Educational Activities Subcommittee of both groups has been especially responsible for this growth.

Special task forces of SOCED are currently developing guidelines for teachers of chemistry similar to guidelines currently available for high school physics teachers. The Guidelines Task Force is composed primarily of high school teachers. The published booklet will not contain information or recommendations on chemistry curricula, but will address problems of teacher load; use of laboratory paraprofessionals; laboratory design; space allocation; safety; professional growth; and budgeting.

The Society Committee on Chemical Education has also been very active in preparing position papers for the Society and contributing to testimony presented before Congress and the National Science Board relating to the NSF Science Education budget. The Committee continues to make known its concerns for the present and future of chemical education in the high schools to policy makers at many levels of government.

Concern for high school issues and needs is not a concern expressed by only a few members and committees of the Society. For example, the Office of Local Section Activities administers a Local Section Program Development Fund. Over the past four years, nearly 50% of grants awarded to local sections under this program have been for high school activities.

The Office of Public Relations has also been very active in high school programming. It has organized a space shuttle competition with the local sections to select a high school student experiment to fly on an upcoming shuttle, the "Get Away Special." Also, the Office is currently developing a multimedia package on, "DNA: Master Molecule of Life" for the high school classroom. The package will contain a filmstrip and sound track; and a teachers' guide with suggested activities, tests, and further reading for the students. The Office has also developed three planetarium shows which are widely used in high schools, as well as the acclaimed "Chemistry and Man" film, and the long established "Man and Molecules" tape series.

Publications by the Office of Public Relations are being used by a growing number of teachers and students. These include the booklet, The Stellar Thread: A Story of DNA, Evolution, and the Immortality of Ideas; and the annual compilation of reports from the forefront of chemical research, What's Happening in Chemistry?

In addition to SOCED and the Committee on Chemical Safety, the Board/Council Committee on Environmental Improvement is also concerned about high school teaching. They have established a subcommittee to examine problems specifically related to the teaching of environmental studies at the high school level. The Board-Council Committee on Chemistry and Public Affairs has also established a group to examine policy issues at the pre-college level.

Clearly, ACS has made an extensive commitment of time, talent, and financial resources to the high school community for both teachers and students. High school programming is an integral part of Society programs and helps keep alive the integrity and vitality of the science to which we have dedicated our professional lives.

American Chemical Society

OFFICE OF THE
PRESIDENT

Fred Basolo
President-Elect, 1982
President, 1983
Immediate Past President, 1984

1155 SIXTEENTH STREET, N.W.
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May 20, 1983

The Honorable Orrin G. Hatch
Chairman
Committee on Labor and Human Resources
United States Senate
Washington, D.C. 20510

Dear Senator Hatch:

I would like to thank you for providing the American Chemical Society with an opportunity to present its views on science education before your Committee on April 18. Following the hearing, you addressed some written questions to Dr. Parry who had testified on behalf of the ACS.

I understand Dr. Parry has replied to these questions on his own behalf. as a distinguished scientist and educator. I am now forwarding the official ACS response to your questions. As Dr. Parry has pointed out in his reply, these two points of view are not at all far apart.

I hope that the American Chemical Society will be able to maintain a continuous dialogue with your Committee on the subject of scientific education.

Sincerely,

Fred Basolo

Fred Basolo

Enclosure

Response to Questions Addressed By Senator Hatch to Science Societies Panel

Question 1:

We have heard every witness at these and Senator Stafford's hearings say that there is a "crisis" in American math and science education. Scientists rarely make such statements unless there is data to document their findings, particularly such alarming ones. A large consortium of educational organizations, however, has come to us and reported that while the problem does, in fact, exist, its nature and magnitude will not be fully known until thorough assessments have been performed by state and local education agencies. Do you believe there is sufficient, reliable information currently available which would negate the need for a lengthy assessment process?

Answer:

The American Chemical Society believes that there is sufficient, reliable information currently available to begin to address the problems now identified as afflicting science and mathematics education in this country. Hence, we do not believe that federal action should await the results of yet another assessment process. However, we do recommend that Congress utilize the upcoming report of the NSB Commission on PreCollege Education in Mathematics, Science, and Technology when formulating remedial legislation.

The time to begin to develop a coherent, long-range federal policy addressing the mathematics and science education needs of our nation is clearly upon us now. As a society we do not have the luxury of taking the time necessary to conduct a state-by-state assessment of the problems that most of us concerned with the quality and quantity of science and mathematics education agree exist in our schools today. Nonetheless we do believe that continuing in-depth assessment should be one component of a comprehensive science and mathematics education policy.

Question 2:

Could the American Chemical Society study be broadened to include the status of education in other science disciplines?

Answer:

The American Chemical Society's study on chemistry education is intended as a companion study to the National Academy's assessment of the current status of chemistry in this country. We intend to follow the same time schedule as the Academy's study, including joint publication. Clearly, expanding the scope of the ACS report to include other science disciplines is not compatible with this schedule.

In addition ACS does not have the expertise in the other science disciplines necessary for such a study, which would more appropriately be the province of other associations. However, the preliminary findings of our task force members suggest that some of our recommendations for chemical education will eventually lead to joint society actions for science education.

Question 3:

Several of you have pointed out that the federal government should be a better "information broker." Would this dissemination of information include the dissemination of pre-college curricula?

Answer:

In the early 60's, the National Science Foundation had a tremendous impact upon science and mathematics education around the country through the development of model curricula. In chemistry, for example, the Chemical Bond Approach and the Chemical Education Material Study catalyzed the publication of a new generation of commercially-available textbooks and locally-adapted programs. The need to update precollege curricula in chemistry for both the college-bound and the general student is now upon us since: (a) chemistry has moved so far in the last 20 years; (b) our understanding of how students learn and retain chemistry knowledge is more sophisticated; and, (c) we have a better appreciation of the need to design different courses for college and non-college bound students.

The most effective and cost-efficient way to disseminate new ideas in the teaching of chemistry is for NSF to sponsor the development of new curricula, and to seek commercial publication of the materials so developed. Curriculum development at the local level is dependent upon the text-books available for purchase; it is also dependent on the existence of sound model curricula to stimulate new and creative approaches to the teaching of chemistry. Thus to answer your question more directly, yes the NSF should be a better "information broker" by more widely publicizing successful programs, and yes this information should include the dissemination of the availability of model precollege curricula. We do not by this suggest that NSF actually distribute books to LEAs around the country.

Question 4:

The Congress enacted a program to assist women and minorities in science several years ago. What can we do, specifically, to increase the participation of women and minorities in science within the context of this science and math education bill that would reinforce or augment the efforts NSF is already making?

Answer:

We would like to see a number of NSF programs initiated or reinstated:

(1) Grants and contracts supporting programs in science and mathematics for female and minority students in elementary and secondary schools, and higher and continuing education. Programs such as science career awareness workshops and apprenticeships programs have been successful in encouraging

young female and minority students to enter scientific careers, and these programs should be continued. Visiting women scientists programs and student and teacher science training programs should be considered.

(2) National Research Opportunity Grants should be initiated to provide opportunities for the advancement of women scientists. We should like to see them provided to women just beginning their careers or resuming interrupted careers.

(3) Reentry programs should be reinstated. These excellent programs funded by the NSF in the past provided opportunities for women to resume careers in science. Many of the earlier programs were directed at women reentering industrial careers. New programs could be directed toward reentry in both education and industry.

Finally, we believe it imperative that women and minorities participate at all levels within the NSF as grant recipients, peer reviewers, visiting scientists, and program administrators. We applaud the formation of the NSF Committee on Equal Opportunities in Science and Technology and of its two standing Subcommittees on Women in Science and on Minorities in Science. We commend their efforts within the Foundation and hope to see them supported.

Question 5:

You have drawn a fairly clear line between the NSF and the Department of Education responsibilities, essentially between levels and not functions. Why do you think NSF should be involved at the elementary school level for teacher training and retraining or improving course content?

Answer:

The American Chemical Society did not state that NSF should not be involved in developing programs at the elementary school level for teacher training and retraining or for improving course content. The Society did state that these programs should be the administered by the Department of Education. We stated this in recognition of the close association of the Department with the elementary education community and its expertise in this area. However, there should be exchange and cooperation between the Department and the NSF to prevent a gulf from developing where the responsibilities of one agency end and the other's begin.

The Society believes that science education should be an integral and basic part of every student's learning experiences from kindergarten through college. We recently sponsored a conference to discuss chemistry course content in grades K through 9. At this conference, it became clear that the coherence and progression of physical science taught from one grade to the next are very important. We would be greatly concerned if the distribution of responsibilities for elementary and secondary education between the Department of Education and the National Science Foundation resulted in a lack of continuity in the teaching of science to our children.

Senator **Hatch**. Thank you, Dr. Parry. You have an extensive statement that we've taken notice of. All of you have excellent statements here. The important thing is that we are making this record for the committee and we're paying very strict attention to what you are recommending.

Dr. Flint.

STATEMENT OF DR. FRANKLIN FLINT, CHAIRMAN, DEPARTMENT OF BIOLOGY, RANDOLPH-MACON WOMEN'S COLLEGE, LYNCHBURG, VA.

Dr. **Flint**. Senator Hatch, I'm pleased to testify before your committee on behalf of the American Institute of Biological Sciences. The AIBS is a consortium of more than 30 professional scientific societies with an aggregate membership of some 60,000 biologists.

As life scientists involved in education and/or in research, we add our voices to those expressing concern about the declining status of science and mathematics education in the United States. Many statements have been delivered on this subject and there seems to be little disagreement as to the existence and severity of this crisis.

Numerous witnesses have been called before congressional panels to point out how this educational crisis threatens America's productivity, economic welfare, and her national defense. Few knowledgeable people would disagree with these statements or question the facts that the dimensions of the problem are multifaceted and permeate the American educational system from the precollege level to the community college, the undergraduate classroom and the graduate universities.

And even as we point with pride to the fact that America takes the lion's share of Nobel Prizes in physics, chemistry, medicine, and physiology, we must pause to ponder the fact that this achievement was built on science education and research done in the past. Prize-winning scientists received their crucial precollege education in the first half of the 20th century. Since then, the investment made by other nations in science education and research has been much larger per capita than in the United States. Future prizes will not be won in such large numbers by American scientists if things do not change.

While there is little debate over these issues, there is disagreement concerning the kind of initiatives the United States should undertake, and who should have jurisdiction over those initiatives—the Department of Education or the National Science Foundation.

The cost of education must be borne by many sectors of the American society, and it is diffcult to assign costs and responsibilities in any precise way. However, it is appropriate that the Federal Government take a leadership role in establishing initiatives to meet this crisis.

Federal leadership in this quest for excellence is now an accepted tradition. The costs for financing this enormous undertaking are beyond the economic means of most of the States or private sector alone, and there is a need for achieving national equity based on the fundamental principles of our society. We also have Federal manpower needs at stake. States offer support to accomplish the needs recognized by the States. However, there are some national needs which it is the responsibility of the Federal Government to address. A scientifically literate population is best equipped to respond to national objectives in a critical and competitive and highly technological world.

Accepting the premise that there is a central Federal role in science education brings us to the question of how the Department of Education and the National Science Foundation should address these problems.

There are two separate, but related, dimensions to the problems in science education: One, the recognition and stimulation of the best teachers and provision for their continued education, and second, the general upgrading of all science and mathematics faculty in individual schools. It would appear that both the Department of Education and NSF have fundamental roles to play in solving both these problems.

In meeting the former, it would seem the National Science Foundation has a key role to play. Educational institutes in the Nation's research universities for teachers selected in a national competition and paid stipends to attend would be highly effective. This could be patterned to some extent on the secondary school institutes sponsored by the NSF during the 1960's and which was referred to in your teachers' panel a few minutes ago. Lessons learned during those institutes should be incorporated into any new program. These programs would give the teacher the prestige of the Foundation, the satisfaction of having been selected on the basis of merit and the regard of attending a prestigious institution. In addition, the use of eminent discipline oriented researchers in developing the contents of these institutes and in teaching the participants would give teachers exposure to some of America's best current research as well as providing much needed professional contacts between the science teachers and these same researchers.

By similar reasoning, it would appear that the Education Department should have some responsibility of improving the quality of science and mathematics instructions in a given locale because that requires that all teachers of those subjects receive attention. The type of programs operated at the State and local school district level, as part of a systematic multiyear plan, with the the U.S. Department of Education serving as the major funding agency, would best meet this need.

There are other areas that should be addressed. A single shot in the arm won't do much to stop the ravages of neglect in our educational system. The process must be ongoing with year after year concern about continuing education of our teachers as a high priority. In meeting this particular need, I feel that careful study and examination of the suggestions made by Dr. James Rutherford, chief education officer of the American Association for the Advancement of Science, should be explored.

I will skip his testimony because you already have it.

I submit to you that there is no dearth of ideals to solve our problems. The colleges and universities have individuals with the abilities to give science education the impetus required to meet the needs of our society. All that is needed to unleash this latent talent is the commitment and leadership at the national level to catalyse the effort.

I wish to suggest three cautionary areas. One, it is important to recognize that emphasis should be given to all fields of engineering, the sciences, and mathematics. These constitute a fabric of human knowledge which becomes distorted if the emphasis is too narrow and is placed on one discipline. Our undergraduate majors in biology need to take strong programs in chemistry, physics, mathematics, and other cognate area if they are to cope with today's problems.

Second, it is important to include research scientists in any long-range effort to improve precollege science education and scientific literacy, because science is an ongoing program and needs to be kept current.

Third, it is important that renewed emphasis on science education make use of the existing infrastructure of the academic sciences to insure economies and effective use of new moneys committed to these objectives.

I do appreciate this opportunity to present my views to this committee. I can assure you of the continuing support of the American Institute of Biological Science to resolve the problems of scientific literacy and education. We will support vigorous action in this field.

Thank you.

[The prepared statement of Dr. Flint and responses to questions asked follows:]

TESTIMONY OF

DR. FRANKLIN FLINT

The Role of the National Science Foundation In Meeting the United States Crisis

In Science and Mathematics Education

Mr. Chairman:

I am pleased to testify before this distinguished panel on behalf of the American Institute of Biological Sciences. The AIBS is a consortium of more than 30 professional scientific societies with an aggregate membership of some 60,000 biologists.

As life scientists involved in education and/or in research, we add our voices to those expressing concern about the declining status of science and mathematics education in the United States. Many statements have been delivered on this subject and there seems to be little disagreement as to the existence and severity of this crisis.

Numerous witnesses have been called before Congressional panels to point out how this educational crisis threatens America's productivity, economic welfare, and national defense. Few knowledgeable people would disagree with these statements or question the facts that the dimensions of the problem are multi-faceted and permeate the American educational system from the precollege level to the community college, the undergraduate classroom and the graduate universities.

And even as we point with pride to the fact that America takes the lion's share of Nobel prizes in physics, chemistry, medicine and physiology, we must pause to ponder the fact that this achievement was built on science education and research done in the past. Prize-winning scientists received their crucial precollege education in the first half of the 20th century. Since then, the investment made by other nations in science education and research has been much larger per capita than in the United States. Future prizes will not be won in such large numbers by American scientists if things do not change.

While there is little debate over these issues, there is disagreement concerning the kind of education initiatives the United States should undertake, ahd who should have jurisdiction over those initiatives---The Department of Education or the National Science Foundation.

The cost of education must be borne by many sectors of the American society, and it is difficult to assign costs and responsibilities in any precise way. However, it is appropriate that the federal government take a leadership role in establishing initiatives to meet this crisis.

Federal leadership in this quest for excellence is now an accepted tradition. The costs for financing this enormous undertaking are beyond the economic means of most of the states or private sector alone, and there is a need for achieving national equity based on the fundamental principles of our society. We also have federal manpower needs at stake. States offer support to accomplish the needs recognized by the states; however, these are some national needs which it is the responsibility of the federal government to address. A scientifically literate population is best equipped to respond to national objectives in a critical and competitive world.

Accepting the premise that there is a central federal role in science education brings us to the question of how the Department of Education and the National Science Foundation should address these problems.

There are two separate, but related, dimensions to the problems in science education: (1) the recognition and stimulation of the best teachers and provisions for their continued education, (2) the general upgrading of all science and mathematics faculty in individual schools.

It would appear that both the Department of Education and NSF have fundamental roles to play in solving both these problems.

In meeting the former, it would seem the National Science Foundation has a key role to play. Educational institutes in the nation's research universities for teachers selected in a national competition and paid stipends to attend would be highly effective. This could be patterned to some extent on the secondary school institutes sponsored by the NSF during the 60's. Lessons learned during those institutes should be incorporated into any new program. These programs would give the teacher the prestige of the Foundation, the satisfaction of having been selected on the basis of merit and the regard of attending a prestigious institution. In addition, the use of eminent discipline oriented researchers in developing the contents of these institutes and in teaching the participants would give teachers exposure to some of America's best current research as well as providing much needed professional contacts between the science teachers and the researchers.

By similar reasoning, it would appear that the Education Department should have the responsibility of improving the quality of science and mathematics instruction in a given locale because that requires that all teachers of those subjects receive attention. The type of programs operated at the state and local school district level as part of a systematic multi-year plan, with the Department serving as the major funding agency, would best meet this need.

There are other areas that should be addressed. A single shot in the arm won't do much to stop the ravages of neglect in our educational system. The process must be ongoing with year after year concern about continuing education of our teachers as a high priority. In meeting this particular need, I feel that careful study and examination of the suggestion made by Dr. F. James Rutherford, chief education officer of the American Association for the Advancement of Science, should be explored.

In earlier testimony, Dr. Rutherford has suggested that electronic capabilities should be developed to satisfy this continuing education need, and that grants should be made available to universities, science museums and scientific societies to develop audio and video tapes and computer programs for continuing education programs.

In addition, Dr. Rutherford has suggested that a satellite educational system be developed and launched to provide 24 hour a day instruction to teachers and students. That idea has definite merit and should be explored more fully by the National Science Foundation, NASA, the Department of Education and other federal agencies with the technological capability and the programmatic concern to not only define the science education crisis, but to develop ways to eliminate the problem.

I submit to you that there is no dearth of ideals to solve our problems. The colleges and universities have individuals with the abilities to give science education the impetus required to meet the needs of our society. All that is needed to unlease this latent talent is the commitment and leadership at the national level to characterize the effort.

I wish to suggest three cautionary areas:

(1) It is important to recognize that emphasis should be given to all fields of engineering, the sciences and mathematics. These constitute a fabric of human knowledge which becomes distorted if the emphasis is too narrow. Our undergraduate majors in biology should take strong programs in chemistry, physics, mathematics and other cognate areas.

(2) It is important to include research scientists in any long range effort to improve precollege science education and scientific literacy.

(3) It is important that renewed emphasis on science education make use of the existing infrastructure of the sciences to insure economies and effective use of new monies committed to these objectives.

I appreciate this opportunity to present my views to this committee. I can assure you of the continuing support of the American Institute of Biological Sciences to resolve the problems of scientifc literacy and education. We will support your vigorous action in this field.

Thank you.

QUESTIONS FROM SENATOR ORRIN G. HATCH
and
RESPONSES FROM FRANKLIN F. FLINT
REPRESENTING THE AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES

Question No. 1

We have heard every witness at these and Senator Stafford's hearings say that there is a "crisis" in American math and science education. Scientists rarely make such statements unless there is data to document their findings, particularly such alarming ones. A large consortium of educational organizations, however, has come to us and reported that while the problem does, in fact, exist, its nature and magnitude will not be fully known until thorough assessments have been performed by state and local education agencies. Do you believe there is sufficient, reliable information currently available which would negate the need for a lengthy assessment process?

Yes, I believe there is sufficient reliable information currently available which would negate the need for a lengthy assessment process concerning the "crisis" in American math and science education. This answer comes from thirty-two years as an instructor in the undergraduate biology classroom, from an examination of SAT scores, from conversations with colleagues, and from activities involving professional organizations. It is true there is some discrepancy of views among various groups and individuals, but there is a common theme that our science programs are not as good as they should be and not as good as they could be. Some of the blame for this is the result of the amalgamation of school districts as an important democratic and social process of the decades of the 60's and 70's. I believe this process has worked sufficiently well for us now to concentrate on excellence in the educational process. I believe there are many influential individuals within minority groups who are in agreement that this quest for excellence in science education can now be attacked successfully.

Question No. 2

Could the American Chemical Society study be broadened to include the status of education in other science disciplines?

Yes, this study could be broadened to include the status of education in all science disciplines. In fact, this has already been done in most cases. The biological sciences have been fragmented with respect to their approach to national issues and disciplinary affiliation. However, the larger professional societies within the broad discipline of biology have been actively involved in the problems of education for many years. Most have a section and/or committee dealing with the issues of education. This is due to the fact that 60% of all biologists are involved in teaching, either pre-college, college, or in graduate schools.

Question No. 3

Several of you have pointed out that the Federal Government should be a better "information broker." Would this dissemination of information include the dissemination of pre-college curricula?

Yes, the Federal Government could be a better information broker. I feel that some involvement of federal agencies in pre-college curricular planning can be good. I say "can be good" because I would assume that the development of pre-college curricula would be done by a contract or grant instrument to leading professionals in the fields of curricular development.

I do not think it would be good for so-called education experts who are career Civil Service employees to handle pre-college curricular development or dissemination.

Question No. 4

The Congress enacted a program to assist women and minorities in science several years ago. What can we do, specifically, to increase the participation of women and minorities in science within the context of this science and math education bill that would reinforce or augment the efforts NSF is already making?

I believe women and minorities are ready to participate fully in science and math education. Many individuals have shown a strong inclination toward science as a career and have definite talent. These persons should be encouraged to utilize these talents, as should every other citizen on an equal and challenging basis.

Question No. 5

You have drawn a fairly clear line between the NSF and the Department of Education responsibilities, essentially between levels and not functions. Why do you think NSF should not be involved at the elementary school level for teacher training and re-training or improving course content?

I feel the NSF has an important job and one which it is qualified to meet if it involves itself only with curricular development and training in science for teachers through workshops, institutes, etc. I believe basic teacher training at the elementary level is best done by people in departments of education. These departments have a long history of successful work with such individuals. Planning an elementary school curriculum which coincides with the child's "readiness to learn" ability is a special field of knowledge. Disciplinary scientists can cooperate in such programs by insisting that science and mathematics be introduced into the curriculum at an early stage and that it be logically arranged so that each grade becomes a stepping stone to the next.

Senator **Hatch**. Thank you, Dr. Flint.

Dr. Boehm, you're our last witness today.

STATEMENT OF DR. ROBERT F. BOEHM, CHAIRMAN, DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING, UNIVERSITY OF UTAH, SALT LAKE CITY, UTAH

Dr. **Boehm**. Dr. Leroy Fletcher is senior vice president of the Council on Education for the ASME and he was unable to appear today and asked me to fill in for him.

My statement has been submitted. Let me just summarize a couple of the key aspects of what I want to emphasize. It is a little different flavor than the basic science teaching. There is a very critical need in technical education. I think when we look at some of the other countries, like Japan, where products and productivity are outstripping us, we find that a percentage of their population that resides in the engineering expertise is much greater than ours.

Let me outline some of the problems that we've got. Enrollments are not a problem. We have more students than we know what to do with. Our enrollment has increased 25 percent per year, even with the establishment of some serious enrollment curtailment. We have many motivated students. The problem is our faculty has grown 1 of a faculty of 20 with no substantial increase for an already poor equipment situation.

Senator **Hatch**. Have you seen the chart in Dr. Parry's statement? The increase of student vis-a-vis the increase of faculty members.

Dr. **Boehm**. Pardon?

Senator **Hatch**. Have you seen the chart that Dr. Parry brought out in his statement? The increase in students goes up like this and the increase in faculty members goes about like that. Is that similar in your field as well?

Dr. **Boehm**. Yes, very much so.

Senator **Hatch**. That's the point you are making here.

Dr. **Boehm**. Right, and the equipment—computers, et cetera—are very critical areas that we're facing right now with regard to productivity. We need a lot of new and, generally, expensive equipment. It's very difficult to fund this from State or Federal sources.

Senator **Hatch**. Do you all agree on that? You need quite a bit of equipment. I get that every time I come out to one of our universities in Utah. They say they just don't have access to the best scientific equipment for teaching purposes.

Dr. **Boehm**. The interesting thing is that we can't even accept gifts, by and large, because many of these gifts require some kind of service contract which could amount to 12 percent per year of the purchase price. That is more than our present total equipment budget is for many of these machines. Recruiting is a very big problem. When we have a job opening, six times as many foreign born students as American students will apply. This leads to language problems in the classrooms, but even more importantly, they are not raised in the technology that we take for granted in our country. This compromises many of their abilities in the classroom. The other problem is the salaries on the outside. I have a young assistant professor who has just been enticed by a nonuniversity entity for twice the salary that he is making at the university. In addition, the research support is very meager. We need this to keep current in our profession—in our professional development to keep up with what's happening in the technology. This same young assistant professor could go outside with a $3 million a year research funding to begin with. With ours, he has to go to NSF with maybe a 40-to-1 chance that he may get some money from them.

What we support are the following items from the NSF: Expand engineering and physical science fellowships, traineeships, research incentives awards, and faculty awards for summer pay; upgrade the undergraduate instructional equipment and its utilization; some kind of tax incentives for leveraging State and private sector resources through matching grants.

In analogy to the saying, "where the tire meets the road," engineering is what accomplishes what science and mathematics puts into motion by forming it into industrial products. Critical needs exist here.

[The prepared statement of Dr. Boehm follows:]

The American Society of Mechanical Engineers
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Testimony before the

Committee on Labor and Human Resources
United States Senate
April 18, 1983

by

Dr. Robert F. Boehm

Professor and Chairman,
Department of Mechanical and Industrial Engineering,
The University of Utah

Representing the
Council on Education,
The American Society of Mechanical Engineers

Introduction

I am Dr. Robert F. Boehm, Professor and Chairman, Department of Mechanical and Industrial Engineering at the University of Utah in Salt Lake City. Dr. Leroy S. Fletcher, Senior Vice President and Chairman of the Council on Education of the American Society of Mechanical Engineers (ASME) regrets he is unable to appear today and has asked me to appear on behalf of the Council.

ASME was formed 103 years ago and has a current membership of some 110,000. It is a volunteer society with an enormous array of activities and resources. Mechanical engineering incompasses an extremely broad range of activities. One way to describe mechanical engineering is, if it moves or holds pressure, from Barnie Clark's substitute mechanical heart to the space shuttle, mechanical engineering was involved.

A consensus exists in the Congress and in the Nation to improve our economic viability both now and in the future by addressing shortcomings in our educational system. Engineering is at the receiving end of that system and is the critical link between concept and reality, between ideas and the market place. The education of engineers to provide this critical link is currently experiencing a crisis of quality. The combined pressures of insufficient faculty, increased enrollment and inadequate instructional equipment are choking off the production of quality graduates.

We are also keenly aware that shortcomings in pre-college math and science education reduce our potential for quality graduates even more. We therefore implore the Congress to reach a consensus as soon as possible and enact legislation to begin to address:

- the shortage of instructional equipment and funds for its use,
- the critical shortage of high quality engineering faculty, and
- the need to increase the quality and quantity of pre-college math and science education.

We believe that this national problem can best be solved through federal initiatives and encouragement in conjunction with the efforts of the states, the private sector and the academic community.

Specific Problems

The shortage of instructional equipment and funds for its use.

The problem has been well documented in prior testimony and has been the subject of a variety of proposed solutions. We do not believe any single legislative initiative or private sector effort will solve this problem. We are therefore strongly supportive of the concept of federal aid with matching assistance from private industry, educational institutions and State governments. The matching requirement helps insure that all the logical participants have a say in what and how much is done. We agree with Senator Tsongas (and others)..."that it is important to mesh the priorities of the private sector with the economic development and educational policies of the states".

I understand that limited personal tax credits or increased deduction allowances for instructional equipment is not within the jurisdiction of this Committee. However, I would like to make a suggestion with the hope that Senator Grassley or Senator Matsunaga will bring it to the attention of their colleagues on the Finance Committee. As an engineer, I am intrigued with the possibility of contributing directly to my own school and then being partially repaid through a tax credit. It seems to make more sense and be much more efficient than sending money to Washington in hope that someone far from the problem will know exactly what is needed at my school. The incentive could vary from 150% credit for lower incomes down to the currently available charitable deduction for higher incomes. Many dedicated teachers spend their own money to supplement meager or non-exsistant equipment budgets. An increased personal deduction allowance, even if capped, could make that personal sacrifice much less necessary while still improving the quality of classroom equipment.

Critical Shortage of Quality Engineering Faculty

I am in the process of hiring three new assistant professors at the University of Utah. All three have PhDs. Due to some extraordinary efforts, I am able to offer $27,000 which is more than some of our other full professors are making after years of service. One of the candidates wants to work for us but has another offer from industry that is almost twice what we have offered. His decision would not be difficult for most of us I am sure. The 1982 average industry starting salary offer to engineering graduates was with a BS in ME was just over $25,200. There are undoubtably a number of causes for the shortage of quality engineering faculty but compensation is certainly a substantial factor that must be addressed by any successful program.

The distinction must be made between quality engineering faculty and simply filling spaces with an available person. Certainly in these times most available jobs are filled and that applies to engineering faculty positions as well. The problem is that some of those filling the positions are not qualified or if qualified are barely acceptable.

In addition a significant number of today's engineering students are being taught by foreign nationals whose command of english is so poor that instruction suffers. Even more importantly, a number of foreign nationals come from very different cultural and economic systems. They are not well prepared to teach engineering in the context of the U.S. value system and cultural environment and do not have the advantage of having grown up with technology. This is not a protest against the technical ability of foreign nationals; indeed, many earned their degrees in the institutions where they are now teaching. It is simply another result of the flow of talented potential engineering instructors into private industry. Foreign nationals who cannot be hired by many companies find teaching a viable alternative and a good way to remain in the United States.

In the NSF budget for 1984, one of the most interesting proposals to help encourage and retain young, talented faculty members is the Presidential Young Investigator Awards program. The ASME has advised Dr. Keyworth and Dr. Knapp of our interest in this program and our willingness to promote the industry-college marriages necessary for fully-funded and successful grants. (A copy of our letter to Dr. Knapp is attached.) In a January 31 press release, Dr. Keyworth stated that "these five year grants will provide new faculty members with up to $100,000 annually for research with half the funds coming from industry."

It is critically important to the success of the Young Investigator Awards program that those states, with large and accessible industrial sources of matching funds, do not run away with the program. If the purpose is primarily to provide incentives to young professors to remain in teaching, we must keep in mind that deserving recipients are located in all fifty states.

If industry is to continue to receive the high level of engineering talent necessary for economic viability, the source of that talent must be protected and nurtured. The federal government must encourage the private sector to do what is in the company's and the country's best long-term interest. Once the pattern of mutual support is established between our schools and private industry, federal support should be gradually shifted to other high priority efforts (as long as it can be done without reducing the potential of cooperative programs then in existence).

Increase the quality and quantity of pre-college math and science education.

One of the problems faced by our engineering faculty is the need to teach remedial courses to incoming engineering students. When shortage of faculty or competition for limited enrollment quotas make it impossible or unnecessary to offer remedial instruction, students who want engineering educations must be turned down. It comes as a shock to aspiring students that their prior education did not prepare them for what they want to do in college.

No one effort will solve the problem nor should we be lulled by the quick, temporary fix. In the current economic situation federal funds are too limited to do more than begin to solve this problem. It is very important that the Congress not try to do a little bit for everyone. The funds should be targeted to the most critical problems first. At our end of the education pipeline, modern equipment is our most pressing need, faculty quality is number two. The pre-college preparation of students entering engineering is a close third in our priorities.

A CONSENSUS VIEW

The 98th Congress has an important opportunity for positive action. Recently the House, overwhelmingly and by a bipartisan vote, approved H.R. 1310, Emergency Mathematics and Science Education Assistance Act. We applaud this move as a positive first step in addressing the current educational crisis.

We support the consensus reached by a broad group of organizations representing diverse elementary, secondary, higher education and private sector constituencies. We believe the appropriate role of the federal government in meeting the pressing problems in math, science and engineering education should include the following:

At the National Science Foundation we urge the establishment of programs to:

- Expand fellowships, traineeships, research incentive awards and faculty awards for summer study;
- upgrade undergraduate instructional equipment and its utilization;
- upgrade and improve instructional programs and materials, in engineering, mathematics, science and technology at all levels; and
- leverage state and private sector resources to achieve these purposes.

At the Department of Education we endorse programs to:

- retrain teachers in effective instructional skills and substantive knowledge;
- support summer institutes and workshops for teacher training initiatives aimed at improving mathematics, science and technology education;
- strengthen and improve the contributions of education research and development; and
- provide student assistance to attract qualified persons to be mathematics and science teachers.

We urge the Senate to adopt legislation that will contain these elements. In this way positive first steps will be taken to reverse the serious decline that is currently threatening our economic and national security. We recognize the necessity of immediate action to deal with the most critical problems and acknowledge that more long range and comprehensive solutions will be necessary. We believe that the programs proposed are consistent with the reality of current budgetary conditions, and will provide an important step toward long-term solution of the pressing problems currently facing math, science and engineering education.

In closing I would like to endorse a statement by Dr. Ed David of Exxon Research, "The most encouraging sign I see is that people have begun to relate the kind of education we have to the economic health of this country".

This statement was prepared by the
American Society of Mechanical Engineer's Council on Education.
It represents the considered judgment of the Council,
experts in the field, rather than an official position of
The American Society of Mechanical Engineers.

Senator HATCH. Thank you very much.

I'm going to submit questions to each of you, in the interest of time here today.

I really appreciate the testimony that we've had and the excellent statements all four of you presented to this committee.

It's almost an unsolvable problem in some ways because we only have so much money to work with. The administration's bill is, we think, probably inadequate as far as monetary figures are concerned. We have a wide disparity of beliefs as to what we should emphasize and what we should not emphasize, but I think your statements will play a heavy role in helping us to resolve some of the difficulties that we have.

I want to thank each of you for coming. We appreciate your giving your time.

At this point, I order printed all statements of those who could not attend and other pertinent material submitted for the record.

[The material referred to follows:]

Association of American Publishers, Inc.

aap

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Testimony of Association of American Publishers
Committee on Labor and Human Resources
United States Senate

April, 1983

The Association of American Publishers (AAP) is the general association of book publishers in the United States. It comprises Professional and Scholarly Publishing; College; International; Direct Marketing/Book Club; School and General Trade divisions. Our some 300 member publishing houses produce the vast majority of general trade, educational, reference, professional and religious books published in this country and found in the nation's libraries as well as considerable related audio-visual materials.

The tradition of including prohibitions against undue Federal influence over education programs is firmly engrained in statute.

In 1958, Congress included in the National Defense Education Act (NDEA), enacted that year, a provision stipulating that "nothing contained in this Act shall be construed to authorize any department, agency, officer or employee of the United States to exercise any direction, supervision, or control over the curriculum, program of instruction, administration, or personnel of any educational institution or school system."

And, in 1970, Congress carried this language over into the General Education Provisions Act (GEPA), the law governing all HEW education programs. It was again spelled out in fuller detail in 1979 in the Department of Education Organization Act, Sec. 103(b) of which states:

> No provision of a program administered by the Secretary or by any other officer of the Department shall be construed to authorize the Secretary or any such officer to exercise any direction, supervision, or control over the curriculum, program of instruction, administration, or personnel of any educational institution, school, or school system, over any accrediting agency or association, or over the selection or content of library resources, textbooks, or other instructional materials by any educational institution or school system, except to the extent authorized by law.

Most recently, in 1983, the 97th Congress included the following section in the Job Training Partnership Act (JTPA):

Prohibition Against Federal Control of Education

> Sec. 145. No provision of this Act shall be construed to authorize any department, agency, officer, or employee of the United States to exercise any direction, supervision, or control over the curriculum, program of instruction, administration, or personnel of any educational institution, school, or school system, or over the selection of library resources, textbooks, or other printed or published instructional materials by any educational institution or school system.

We urge that a similar provision be included in the enabling legislation for the National Science Foundation, the National Science Foundation Act of 1950, as amended. Such a provision would be consistent with well-established Congressional policy. It would provide insurance against any possible suspicion that currently expanding NSF science and engineering programs might unduly encroach upon state, local and university prerogatives and would be an effective instrument in helping NSF minimize such embarassments of the type suffered during the 1970's as a result of the MACOS project.

TESTIMONY OF SENATOR DANIEL K. INOUYE before Senate Committee on Labor and Human Resources

Mr. Chairman:

I am pleased to be able to discuss with you my proposal for the improvement of college programs in math, science and engineering.

This bill is quite different from most of those which the committee is presently considering. My bill is small in both scope and in funding requirements because it is designed to address a narrow, though important, issue. It does not presume to deal with all aspects of the problems our country faces in math and science education, but rather with an aspect of this problem that has been neglected.

I am proposing that the Congress authorize $12 million to establish a program which would enlarge science education opportunities for students who do not have access to good programs in math, science, and engineering. This will be achieved in two ways. First, the program would enable eminent researchers and teachers to spend a semester or a year helping in various ways institutions of higher education located in remote areas throughout the country or institutions serving a large number of minority or economically disadvantaged students.

Second, it would authorize grants to faculty members from these same institutions to spend a year at a major university upgrading their teaching and research skills, and then return to their own institutions to upgrade the educational programs there. At the present time, no program like this, in math, science or engineering, is supported by any of the federal agencies or by any private institution. The National Institutes of Health has been running a similar program in the biomedical sciences. It is now time to improve and expand this concept to the technological sciences, which are so important for our nation's security and economic well-being.

Improved preparation of all citizens in fields of mathematics, science, and technology is essential to the development and maintenance of our economic strength, military security, commitment to the democratic ideal of an informed and participating citizenry, and international scientific leadership.

As the total number of 18-year-olds in the population continues to decrease into the 1990s, the percentage of high school graduates entering pre-professional college level courses in science and engineering must increase to meet future needs. We must develop and utilize the talents of all Americans, including women and minorities and those from the poorer areas of our country. We can no longer depend on a fraction of our population to meet 100 percent of scientific and technological personnel requirements. We cannot afford to waste the talents of any of our human resources.

The problems we face in our educational systems are multifaceted and, therefore, require action on many different levels.

I would like to remind you that we have faced a similar problem before. Although our solutions proved successful, in part they were also partially responsible for the situation we face today.

In 1958, soon after the Soviet Union launched the space age with its Sputnik space craft, the Congress passed the National Defense Education Act. The Act was designed to improve science education at all levels from kindergarden through graduate school, to increase the numbers of teachers, and in general to improve the technological skills of our future work force so that we could compete successfully with the Russians.

The United States did, indeed, land the first person on the moon in 1969, and yet, through the 1970s, many of our scientists and engineers could not find employment in the declining aerospace industries and in our schools and universities. As a result, enrollments declined and many scientists and technicians left their professional fields. Today, we have serious faculty shortages in our engineering schools and in science and mathematics at the primary, secondary, and college levels. Demand from the private sector has lured away many teachers, and our depleted pool cannot replace teachers in sufficient number. Concommitantly, graduates of many of our schools lack the skills necessary to find employment in our increasingly technological society.

The bill that I have proposed for your consideration is both unique and modest in cost. It will cost $12 million a year and will directly benefit between 100 and 200 institutions of higher education. I hope that the committee will include it in its omnibus legislation to improve science education in our nation.

Peer

Project on
Equal Education
Rights

A Project of the
NOW Legal Defense
and Education Fund

Testimony of

Holly Knox, Director, Project on Equal Education Rights

Submitted for the Record

of

Hearings on

The Education For Economic Security Act

in

The Senate Committee on Labor and Human Resources

April 18, 1983

The Project on Equal Education Rights of the NOW Legal Defense and Education Fund has been working since 1974 to promote equal opportunities for women and girls in the public schools. With the dawn of the "computer era", PEER focus is on increasing access for women and minority males in mathematics, science, and technical education as our top priority.

We share the grave concern that educators, business leaders and policymakers have for the quality of mathematics and science education. All children need to be adequately prepared for a future in which mathematics, science and technical knowledge will be essential tools for success in the workplace. Too often, however, policymakers overlook those groups -- women and minorities -- that have historically participated at a low rate in these fields.

We understand that legislation aimed at upgrading math and science education like S. 530 is critical and we commend you for taking leadership on this issue. We would like to share with you our views on the legislation and offer a few suggestions about how it could be improved.

Never before in history has there been such a great need for persons skilled in mathematics and science. Yet our educational system is singularly ill-equipped to serve this need at the present time. For example, there has been a drop in mathematics and science course-taking over the last two decades. Between 1960 and 1977, the proportion of public high school students enrolled in science courses declined from 60 to 48 percent. There has been a parallel drop in achievement -- math SAT scores for college-bound students have declined steadily over the last 18 years through 1980 and only recently has this trend begun to reverse itself. The National Science Board Commission on Pre-College Education in Mathematics, Science and Technology reports that in 1981, 50 percent of teachers newly employed nationwide to teach secondary science and mathematics were actually uncertified to teach those subjects.

Experts predict critical shortages in the fields of engineering, computer science, mathematics and the physical sciences. According to the Bureau of Labor Statistics, there will be a shortage of over half a million computer operators, systems analysts and technicians by 1990. The National Engineering Manpower Project of the Electronic Industries Association predicts that the demand for electrical and computer engineers will exceed supply by almost 40,000 by 1985.

Yet the absolute number of high school graduates in 1985 will be 15 percent lower than in 1975, according to the Southern Regional Education Board. The National Center for Education Statistics estimates that between 1980 and 1990 the overall minority school age population will increase 4.9 percent, while the white will decline 9 percent. By 1990 the youth cohort will be 30 percent minority nationally.

Given that the majority of workers -- 53 percent -- are women and minority males, it is clear that any substantial increase in high technology workers will emerge from the very groups that have historically been underrepresented in science fields.

The National Science Board Commission in their report, Today's Problems, Tomorrow's Crises, stated that "to meet the country's needs for excellence, creativity, and innovation in its scientific work, we must develop and utilize the talents of all Americans, particularly women and minorities, now currently underrepresented in the science and engineering professions."

Dr. Cora Marrett, the Chair of the National Science Foundation's Committee on Equal Opportunity, couched the problem in even more urgent terms during the December meeting of the National Science Board Commission. "(W)ithout access, without equality of opportunities, the very health of the scientific enterprise of this nation is threatened and the health of the nation in general....(T)he focus of the problems of access of the underrepresented is a focus on enhancing the scientific manpower of the nation."

In fact, the very jobs that are increasing the fastest are the very jobs where women and minorities have not been employed. Jobs like machine mechanic, computer systems analyst, computer operator and computer programmer are among the Department of Labor's list of the 30 most rapidly increasing occupations for the 1980s.

In these and other critical fields, women and minorities have been historically and consistently underrepresented:

- In 1976, women were 40 percent of the labor force but held only 13 percent of the jobs in math, computer and life science.
- Blacks hold only 2.4 percent of all engineering jobs.
- In 1981, Black females were about 2 percent of all computer specialists.
- Women are only 4 percent of employed engineers.

- Blacks account for only 5.1 percent of those employed in mathematics and computer science fields.

Judging from the educational programs that prepare future professionals in these fields, women and minorities are likely to stay substantially underrepresented in scientific and technical careers. While the trend has been slightly upward over the last decade, females and minorities are still enrolling in education for these fields in dramatically smaller numbers than white men:

- In 1978, Blacks received six percent of the bachelor's degrees in computer science; Hispanics, 1.8 percent and American Indians 1.3 percent.
- Only 20 percent of the students enrolled in technical vocational programs are women.
- A 1977 study of entering freshman at the University of Maryland showed that 63 percent of white men in the class had 3.5 years of precalculus high school math compared to only 31 percent of white women, 27 percent of Black men and 19 percent of Black women.
- In 1981, women received nine percent of the bachelors degrees in engineering.
- A 1981 survey of 113 school districts in Michigan found that boys outnumbered girls two to one in computer math courses.

Traditionally-female occupations are undergoing enormous change. An estimated 80 percent of working women are now concentrated in occupations which are rapidly declining or becoming obsolete as a result of technological advances. Jobs such as bank teller, telephone operator and clerical worker are undergoing major changes which will result in dramatically fewer jobs available in fields in which women have traditionally been concentrated. This revolutionary change in the nation's labor market will have a devastating impact on women. Not only will women face job displacement, but they also will face long-term or even permanent unemployment because few will have the resources or opportunity to acquire the necessary skills to enter and advance in the technical job market.

Special Barriers for Young Women

Perhaps the greatest barrier to the achievement and participation of young women in mathematics and science is the persistent cultural bias that these fields are properly in the male domain. The consequences of this perception are severe.

In 1972, sociologist Lucy Sells conducted a systematic study using a random sample of freshmen admitted to Berkeley that fall. She found that 57 percent of boys but only 8 percent of the girls had taken four full years of high school math. The situation had changed in 1981. In that year, one-half of college-bound girls compared to two-thirds of college-bound boys had completed four years of high school math. Despite this improvement, the gap in enrollments, especially in advanced courses, persists.

PEER's own study of math enrollments in 113 school districts in Michigan in the fall of 1981 confirmed this pattern. Boys outnumbered girls two to one in computer math courses: in one school district the percentage of girls in computer math was as low as 22 percent. Girls were 40 percent of the students in calculus and 43 percent of the students in trigonometry. We also found advanced science courses with enrollments as low as 19 percent female.

This difference in course-taking is chiefly responsible for the lower achievement rates of girls that many studies have reported. While boys and girls tend to do equally well in math at elementary school levels, girls' math scores drop behind in junior high and fall further behind at the high school and college level. These findings are consistent across numerous studies including those of the National Assessment of Educational Progress and the SAT.

There has been a great deal of research undertaken in the last decade aimed at understanding what factors influence students' choices concerning math and science education. Much of the research points to two key groups as powerful influences on young people's career choices: parents and teachers.

A 1980 study funded by the National Institute of Education to look at what factors influence the achievement and participation of women in mathematics turned up some interesting insights as to why children of both sexes choose to take math courses. The study found that three most important considerations that go into the decision to take math are:

- positive attitudes toward mathematics;
- perceived need for mathematics for future career and educational plans; and

- influence of significant others, including parents, teachers and counselors.

Parental encouragement and support are important for both boys and girls, according to the study. The best predictor of what courses girls would take was their perception of their father's educational expectations. In general, the study leads to the conclusion that girls receive less encouragement than boys, have less positive attitudes towards math and see math as less useful for their future careers.

Teachers also play a pivotal role in a girl's choice to pursue math. In her paper, "Mathematics Education Research: Implications for the 80's," Dr. Elizabeth Fennema points out some ways that teacher behavior can have the unintended effect of discouraging girls from taking math classes. Some teachers -- but not all -- have higher expectations and demand more from boys than girls. Teachers interact, both positively and negatively, more with boys than girls. Teachers ask more questions and more difficult questions of boys than girls. Other research has shown that these differences in teacher behavior are more extreme with high ability children.

On the other hand, teachers can have a tremendous positive influence. Many women who have become successful in scientific fields report that it was the influence and encouragement of a single teacher that made the difference. Such things as exposure to same-sex role models, sincere praise for the job well done, and advice on the value of math and science for future careers, all tend to make a big impact on girls' choices;

Additional Barriers for Minority Students

Minority students, like female students, lack role models in scientific and technical careers and are often not encouraged to think of these careers as possible for them. Minority students are also more likely to attend schools where the quality of mathematics teachers and course offerings are poor or minimally satisfactory. Too often, they may become stuck in remedial courses, which may not allow them time for advanced mathematics and science courses. For some minority populations, the English language is also a barrier.

Programs That Work

Over the last 15 years, intervention programs have been developed with an aim toward removing some of these barriers to achievement. In 1980, the American Association for the Advancement of Science prepared an inventory of programs for women and girls in math and science between 1966 and 1978. They found 315. Intervention programs for minorities include the National Association of Pre-College Directors, a network of 14 programs aimed at increasing minority participation in math, science and engineering. These programs pursue a variety of intervention strategies, including career awareness programs, inservice training for teachers and administrators, parental involvement and remediation of students. The striking thing about many of these programs is that they work -- and they are often inexpensive to implement. Some examples include:

- EQUALS. Located at the Lawrence Hall of Science in Berkely, California, EQUALS is a low-cost training program designed to provide practical assistance to teachers, counselors and administrators, service grades K-12. Since 1977, 2,000 educators in California and 2,000 educators in 25 other states have participated in the EQUALS program. Evaluations show that in schools where the EQUALS program has been used for two or more years, there is an increased participation of girls in advanced math class, and the students of EQUALS teachers (both boys and girls) have improved attitudes towards mathematics and increased interest in mathematics-related career fields.

- Mathematics, Engineering, Science Achievement (MESA). Since it began in 1970, MESA has delivered a variety of educational services aimed at stimulating enrollments and success of minority students in college preparatory high schools in California. Approximately 500 MESA students now graduate per year with the educational background they need to succeed in mathematics, engineering and the physical sciences. More than two-thirds of MESA's graduates select math-based majors in college.
- Career Oriented Modules to Explore Topic in Science (COMETS). The COMETS project at the University of Kansas focuses on using role models to encourage science career interests among female high school students. Each of 24 lessons describes science activities which role models can use to arouse interest in a particular science concept and to explain how the science concept is applied in her career field.
- PEER Community Campaigns. PEER is currently working with community groups in four states in an effort to improve access to quality education, particularly in the math and science area. Reports from the

> Michigan project, PEER's longest running project, demonstrates the kind of impact community involvement can have at the local level. The increased community awareness of the importance of math and science education to girls' futures has resulted in concrete changes. Citizen interest generated a pioneering study of math enrollments, now being used extensively by Michigan's teachers, administrators and parents. Community groups in two towns have initiated programs aimed at improving attitudes and increasing awareness among both teachers and students concerning math and science education as a result of the study. Educators, having perceived the need to make changes, use community interest and involvement in the study as evidence that parents support these changes.

One significant effect of these programs is that, although they may originally focus on a special population, all students actually benefit. Programs focused on career awareness can capture the interests of minorities and non-minorities. Both boys and girls can benefit from programs to reduce math anxiety and avoidance. The EQUALS program equips their participation with creative, imaginative and fun ways to teach mathematics -- techniques that will stimulate all students. One Michigan high school teacher reported that when, as a result of the Michigan project, the school started encouraging girls to take physics, they got more boys too. They increased the number of physics classes from two to five. The results of these intervention programs offer solid support for Dr. Marrett's statement that, "It is to our advantage to start with segments that seem to have the greatest problems, because if we can solve those, we can solve anything."

Implications for S. 530

- General. All state and local programs receiving federal funds aimed at improving mathematics, science and technical education must build in efforts to increase the participation of traditionally underrepresented groups.

  1. All teacher training must include instructional methods and materials aimed at removing barriers to achievement and increasing the participation of females, minorities and other traditionally underrepresented groups in mathematics, science and technology-related educational programs and careers.

     Given that there are differentials in the educational experience of boys and girls, minorities and non-minorities, any inservice training must include components that help teachers reach out to involve girls and minority males. Awareness is the key. School administrators, school board members, counselors and teachers all need basic awareness training about the special barriers young women and minorities encounter in math and science education. We recommend that the techniques and models already pioneered and proven in successful intervention programs be incorporated into inservice training and retraining.

2. Curricula and instructional materials developed under this Act must be designed to appeal to boys and girls, minorities and non-minorities. Existing science and mathematics texts often omit and stereotype women, girls and minorities. For example, the pronoun "he" might be used exclusively in word problems or the word problem themselves might describe traditionally-male activities that girls may be unfamiliar with or disinterested in. "Children, Television and Science: An Overview of the Formative Research for 3-2-1 Contact" produced by the Children's Television Workshop showed that girls perferred shows with female leads, that depicted relationships between people and that focused on animals. This gives a clue to developing a science and math curriculum that interests both sexes, not just boys. At the very least, any curriculum that is developed for math and science classes or for computer use must be free of sex and race stereotyping and bias.

- Federal Level. There should be established at the federal level a $10 million program for developing, reviewing and disseminating model programs and curricula aimed at expanding the participation of women and minorities.

We are concerned that there is no funding for national level development, dissemination and evaluation of materials and model programs. In fact, this kind of centralized effort is sorely needed. Too often local school districts operate in isolation and are unaware of what resources are available. There are scores of programs already in existence with proven track records but they are not widely know. It is duplicative, costly and inefficient to have some 16,000 school districts all inventing some version of the wheel.

There are many fine intervention programs already in existence. But rapid technological and societal change mandates a continued commitment to developing new programs to help solve those problems that are just beginning to surface -- such as inequities in microcomputer use in schools.

- State Level. The states should be required to spend 10 percent of their share of federal funds for model, exemplary, or statewide programs to expand the participation of women, minorities and underrepresented groups in mathematics, science and technical education programs and careers, and for competitive incentive grants to local school districts that want to make increased participation of underrepresented groups a priority.

Involvement of Groups Outside the Formal Education System.

Many successful intervention programs, such as EQUALS, are located outside the formal educational system. More emphasis should be put on involving and supporting local programs that have already developed some solutions to the problem, particularly in the area of involving girls and women in math and science programs.

Parental Involvement

Parents are a key group. Because parents have such a great influence on their children's career choices, it is critical that parents become aware of the problem and if possible become involved in the solution. One of the purposes of local funds should be developing parent-school partnership programs.

Research and Development

The National Institute of Education has already done a fine job of funding research to identify the special barriers women face in math and science education. More research needs to be done relating to minority involvement and on solutions. Additional research should explore the emerging issues involved with the growth of computerized instruction. Very little research has been done on equity in computer use, for example, poorer school districts are less likely to have computers than richer. Some anecdotal evidence suggests that boys may use computers in schools more than girls. This could have serious implications. We recommend that one of the priorities for research and development be investigating and finding solutions to those factors that might discourage women and minority males from pursuing math and science education.

Formula

The formula for dividing federal funds among states and local school districts should be weighted so that poorer school districts get a proportionately larger share of funds. The Senate should adopt the formula contained in H.R. 1310, the "Emergency Mathematics and Science Education Act."

Conclusion

The legislation is a good start toward improving the quality of math and science education but much more needs to be done. We expect, also, that the funding level that is proposed for this legislation will not be sufficient to accomplish all that needs to be done.

Opening the doors to math and science careers to women and minority males is not simply an issue of fairness and equity. Women and minority males are now the majority of our workforce. Unless we tap this pool of workers, shortages in skilled workers will get more serious. Lesiglation aimed at improving math and science education must take into account the lower participation rates of women and minority males in these programs and take steps to ensure that our educational system better serves their needs. This is absolutely crucial.

THE
NATIONAL
FEDERATION
OF
BUSINESS AND PROFESSIONAL WOMEN'S CLUBS, INC.
of the United States of America

2012 MASSACHUSETTS AVENUE, N. W.
WASHINGTON, D. C., 20036
293-1100

April 20, 1983

Sen. Orrin Hatch, Chairman
Senate Labor and Human Resources
Committee
4230 Dirksen Senate Office Bldg.
Washington, D.C. 20510

Dear Senator Hatch:

The National Federation of Business and Professional Women's Clubs, Inc. (BPW) wishes to commend the Senate Labor and Human Resources Committee for addressing the important issue of math and science education through S. 530, the "Education for Economic Security Act." BPW promotes full participation, equity and economic self-sufficiency for working women. Since 1919, BPW has supported opportunities for women to work in the sciences and vocational fields.

As one of the largest working women's organizations in the United States, BPW is deeply concerned with the future of women in the workplace. Our concern over this issue prompted BPW to take action through the development of the BPW National Council on the Future of Women in the Workplace. This Council, which is chaired by Eleanor Holmes Norton, was formed this year to monitor activities in the federal government and to initiate dialogue with representatives of the corporate world in order to alert members to actions and policies which may have a critical impact on working women. The Council is also studying trends in the workplace and in career counseling to prepare women for the jobs of the future.

BPW's 155,000 members work in their individual communities to promote opportunities for women in the professions. Their jobs in the future will be greatly influenced by the success of bills such as S. 530. At present, while women are entering the workforce at increasing rates, the jobs they take are still predominantly in stereotypical "women's" occupations. In 1981, there were 47 million women in the workforce, making up 43 percent of all workers. Of these women, 35 percent worked in clerical occupations, 21 percent were service workers, 15 percent blue-collar workers, 7 percent sales workers, 6 percent school teachers, 6 percent managers and administrators, 10 percent in other professional fields, and 1 percent farm workers. These statistics clearly show that women are in need of wider job opportunities.

The proportion of women studying in fields such as science and engineering has increased, but their total numbers are still small. From 1970 to 1980, the percentage of bachelor's degrees in science and engineering fields that went to women increased from 26 to 37 percent; and the total number of women earning doctorates in these fields more than doubled, with women taking 22.6 percent of these degrees in 1980 as opposed to 9.2 percent in 1970. However, percentages can be misleading; 7.2 percent of engineering degrees went to women in 1979, but this still means a total of only 6,208 women receiving these degrees, compared to 74,000 men.

As computers become more and more important, we will undoubtedly see many people, both men and women, getting training in mathematics and science. This is an important step into the future, but we are concerned that women are still concentrated at lower levels in these fields. Women do earn 40 percent of the bachelor's degrees in mathematics and statistics, but only 10 percent of the doctorates. Women also fall into the less "marketable" specialties within these fields. For example, in 1979 women earned over 47 percent of associate degrees in data processing technologies. However, they earned 93 percent of the degrees specializing in keypunch operations (506 of 543), but only 13 percent of the more lucrative specialty in data-processing maintenance (43 out of 328 degrees awarded to women).

As a national organization committed to removing inequality from our American society, BPW believes that a serious move must be made to improve the numbers and occupations of women in the math and science fields. S. 530 attempts to address the problems our society is now encountering with the lack of qualified professionals to teach math and science. We wish to urge that S. 530 also promote the increase in participation of traditionally underrepresented groups, such as women and minorities. In order to be fully effective we recommend the following provisions:

- All state and local programs receiving federal funds aimed at improving mathematics, science, and technical education must build in efforts to increase the participation of traditionally underrepresented groups. For example:

1. All teacher training must include instructional methods and materials aimed at removing barriers to achievement and increasing the participation of females, minorities and other traditionally underrepresented groups in mathematics, science and technology-related educational programs and careers.

2. Curricula and instructional materials developed under this Act must be designed to appeal to boys and girls, minorities and non-minorities.

- There should be established at the federal level a $10 million program for developing, reviewing and disseminating model programs and curricula aimed at expanding the participation rate of women and minorities.

- The states should be required to spend 10 percent of their share of federal funds for model, exemplary, or statewide programs to expand the participation of women, minorities and underrepresented groups in mathematics, science and technical education programs and careers, and for competitive incentive grants to local school districts that want to make increasing the participation of underrepresented groups a priority.

BPW has historically worked toward the improvement of opportunities for women through education in industrial, scientific, and vocational activities. Our belief that these fields are important to women and to equity in the workplace leads us to urge all Senators to support S. 530.

Sincerely,

Jeri S. Libner

Jeri S. Libner
National President

Kristine Iverson
Professional Staff Member
Committee on Labor and Human Resources
U.S. Senate
Dirksen Senate Office Building 4230
Washington, D. C. 20510

Dear Kris:

Enclosed please find a copy of Higher Education's Agenda in Mathematics, Science and Technology Education. This was the joint product of a broad range of associations interested in the current legislation. On behalf of these groups, I request that this document be included in the hearing record on S. 1285, Education for Economic Security Act.

Sincerely yours,

Irene

Irene Spero
Assistant Director for
Governmental Relations

IS/adm

Encl.

HIGHER EDUCATION'S AGENDA IN MATHEMATICS, SCIENCE AND TECHNOLOGY EDUCATION

Background

America's productivity, economic welfare and national defense are threatened by the growing crisis in our education system. Awareness of this problem manifested itself during the 97th Congress in numerous legislative proposals, reports of the National Science Board Commission on Precollege Education in Mathematics, Science and Technology, the proliferation of private sector programs, and widespread media attention.

The dimensions of the problem are multifaceted and permeate our educational system from the precollege level to the community college, the undergraduate classrooms and the graduate universities. There is considerable evidence of the decline of our scientific educational system:

- documented declines in student achievement in mathematics and sciences. Average science and mathematics scores on standardized college entrance tests have been dropping steadily for 20 years;

- a serious shortage of qualified mathematics and science teachers. During the 1970's the number of secondary school mathematics teachers being trained declined 77 percent; science teachers being trained declined 65 percent. Some 50 percent of newly employed teachers nationwide are currently uncertified and unqualified to teach mathematics and science. This situation is exacerbated by the rapid departure of trained classroom teachers for better paying jobs in industry;

- at least 2,000 vacant faculty positions in university engineering departments. These vacancies have resulted in enrollment limits which, in turn, impede the training of adequate numbers of B.S. engineers;

- the obsolescence of much of the instrumentation and equipment used in college and university laboratories has been well documented;

- tens of thousands of technician openings are going begging even as the national rate of unemployment approaches 11 percent. The Congressional Budget Office projects that new technologies will make 3 million more jobs obsolete by the end of this century;

- secondary students are taking fewer courses in math and science than in years past, and fewer courses are being offered. Half of all U.S. high school students take no mathematics after the tenth grade, while in other industrialized nations, particularly Japan and Germany, increasing emphasis is being placed on science and mathematics education;

- since 1972 there has been a 54 percent decline in the number of Ph.D.'s awarded in engineering yearly to U.S. nationals, while Ph.D.'s in engineering awarded to foreign students have more than doubled; and

- Japan, one of our primary competitors in the world marketplace, produces twice as many engineers as we do even though their population base is half ours. From 1970 to 1977 the number of engineers per 1,000 workers increased by 48 percent in Japan and decreased by 9 percent in the U.S.

There is bipartisan recognition of this growing crisis. President Reagan, in a message to the 1982 National Academy of Sciences Convocation on Science and Mathematics in the Schools, declared: "The problems today in elementary and secondary school science and mathematics education are serious -- serious enough to compromise America's future ability to develop and advance our traditional industrial base to compete in international marketplaces." The Special Task Force on Long Term Economic Policy of the House Democratic Caucus observed in its report Rebuilding the Road to Opportunity: "in the future, a well-educated, well-trained workforce will be essential to sustained economic growth . . . the future will be won with brainpower . . . The research we must undertake to produce new technologies requires talent -- yet we are not graduating sufficient numbers of scientists, engineers and technicians."

The Federal Role

Although there is now general agreement on the dimensions of the problem, there is no consensus on the solution. The higher education community views the current crisis with alarm. Constructive actions at the institutional, local, state, and national levels are necessary to forestall a further deterioration.

We believe the federal government must play a central role in providing leadership and support for a variety of initiatives outlined in the following pages. Sustained federal investment is required because the problems are national in scope and because failure to resolve them would have grave implications for our national well-being and defense capability. These investments will maximize the return on scarce federal resources, encourage local and individual initiatives, minimize federal control of these efforts, and provide incentives for collaboration among all sectors.

America's postsecondary institutions -- two-year, four-year, and graduate -- all have a major role to play in restoring our economic health and bolstering our national defense. Their resources should be directed to the most critical problems that beset the science education system so that adequate numbers of qualified mathematics and science school teachers will be trained; education for technology and science-related careers will be provided; the proper research environment, experience and tools to train the next generation of scientists, engineers and researchers will be encouraged; and research to improve instruction and the educational uses of information technology will be supported. With such steps students will be sufficiently science-literate to live in an increasingly technological world and have the opportunity to prepare for careers in the sciences; and currently employed teachers, engineers, scientists and researchers will have opportunities to upgrade their skills.

Thus we urge the 98th Congress to enact major legislation that will enable colleges and universities to further fulfill their mission as a vital force in solving the current science, mathematics, and technology education crisis. The higher education community recognizes the interrelationship among all levels of education in resolving the crisis and supports the efforts of the precollege sector to solve their own unique and compelling problems. However, this paper attempts only to address the crisis from the perspectives of higher education.

Proposed Federal Program

The higher education community -- collectively listed at the end of this paper -- supports the establishment of five new programs to be administered by the Department of Education and the National Science Foundation. These programs represent the top priorities of the higher education community regarding science, mathematics and technology education. Each is an essential component of the total effort needed in this area.

For the Department of Education, we propose two programs: a $200 million program for teacher training initiatives to improve science, mathematics and technology education, and a $25 million program to strengthen educational research in these areas.

For the National Science Foundation, we propose three programs: a $100 million program providing opportunities for teachers, young scholars and researchers through expanded graduate fellowships, new traineeships and faculty research awards; a $50 million program to upgrade and improve instructional programs on all levels; and a $200 million program to upgrade instructional equipment and its utilization.

The total $575 million dollar federal investment proposed provides a significant number and variety of new awards to individuals, schools, and colleges. Coupled with local, state and private sector initiatives, these programs will make a substantial contribution toward the revitalization of the science education in the nation.

In embarking on this new federal effort in sciences, math and technology education we must acknowledge the importance of a sustained national commitment to basic research. Without quality research programs, the education enterprise will wither. Our proposal for new federal support of science education should be viewed as an integral part of this commitment. Both research and education are necessary for the economic vitality and defense strength of the U.S. Neither should be funded at the expense of the other.

Title: A Program for Teacher Training Initiatives to Improve Science, Mathematics and Technology Education

Agency:	Department of Education
Authorization:	$200 million
Target:	3,000 grants at up to $200,000 each to schools and colleges

We propose the establishment of a grant program for schools, colleges and universities to be administered by the Department of Education with proposals to be evaluated through a peer review process involving consultation with NSF to identify field readers. The purpose of these grants is to encourage the linkage between colleges and universities and public and private elementary and secondary schools in the improvement of science education. Grants would allow maximum institutional flexibility to be responsive to local needs, and would be awarded according to plans developed by the recipient institution in collaboration with one or more public or private schools or school districts and other appropriate agencies or councils. Priority activities might include, for example:

(1) summer institutes and workshops and a parallel program of inservice education, conducted by higher education institutions across all states and regions to provide practicing teachers and supervisors with up-to-date science and mathematics information and pedagogical concepts;

(2) projects to enhance the capacity of schools and colleges to meet the professional needs of both new and practicing teachers, including faculty development activities; and

(3) support for exemplary state, local and institutional efforts to attract, retain and motivate teachers to pursue careers in precollege mathematics and science education, as well as identification of teacher training projects providing nationally significant examples of campus-based inservice, school site staff development, and the integration of substantive knowledge in mathematics and the sciences with effective teaching strategies, and the dissemination of information about these programs.

Title: A Program to Strengthen Educational Research in Mathematics/Science and Technology Education

Agency:	National Institute of Education, in consultation with the National Science Foundation
Authorization:	$25 million
Target:	New grant competitions for specific research yielding 10 major programmatic awards, and up to 200 individual research grants.

Research on student learning and school and college instruction in math, science, and technology education (particularly focused on secondary schools) is an essential resource for other federal, state and local programs for improving math and science education.

We propose a new program to strengthen teaching and learning research through grants focused on the identification of successful instruction and the application of cognitive research to improved instructional programs. The program will support large scale research competitions dealing with:

(1) research on thinking, teaching and learning related to instruction in math, science and technology;

(2) research on the uses of modern instructional technologies; the status, means of assessment, and selection of instructional software and other mathematics, science and technology education materials;

(3) research on local, state and institutional policies enhancing or inhibiting the recruitment, retention and professional development of school and college math and science faculties; and

(4) research on school, institution and state needs and operations as they relate to the development and support of remedial programs at all levels of education.

Title: A Program of Opportunities for Teachers, Young Scholars and Researchers through Expanded Fellowships, New Traineeships, Research Incentive Awards, and Faculty Awards for Summer Study

Agency:	National Science Foundation
Authorization:	$100 million
Target:	$15 million to expand existing graduate fellowships and to create 600 new graduate fellowships; $15 million for new institutional traineeship programs; $50 million for 1,000 new faculty research incentive awards; $20 million for faculty awards for summer study sabbaticals and special research opportunities.

We propose the establishment of a series of new and expanded programs to provide fellowships, traineeships, summer study support, research incentive awards, and faculty renewal awards to increase the production of scientists, engineering faculty, researchers and science educators, and to upgrade teaching faculty.

Four programs should be supported in this area:

(1) An expanded Graduate Fellowship Program. The structure and effectiveness of the NSF Graduate Fellowship Program, once a premier symbol of the nation's commitment to excellence, has diminished steadily over the years. The NSF fellowship program should be expanded by increasing the number of awards and the amount of the stipend. To achieve this, we propose at least doubling the amount of money available for these fellowships (from $15 million to $30 million) and increasing by approximately one-third both the number and size of the current awards (from 1,400 to 2,000 and at least $15,000 rather than $10,900 per award).

(2) A new $15 million Traineeship Program for science, technology and mathematics educators. Awards of up to $150,000 would be made to colleges and universities. Trainees would be selected by participating departments, schools and institutions from among individuals with demonstrated potential to excel as science, technology and mathematics educators at elementary/secondary and undergraduate levels. Institutions receiving traineeships would gather education specialists and faculty from departments of science, mathematics and technology to create for the trainee a new or improved quality program for preparing the next generation of science educators.

(3) A new $50 million Young Faculty Research Incentive Awards Program. The challenges facing young faculty who seek to establish their first research programs are almost overwhelming. A program offering stable support (averaging $50,000 per year per

award) to assist them in starting academic research careers would help to sustain the quality and flow of individuals into key fields of science, mathematics, engineering and technology. 1,000 awards would be authorized to average $50,000 per year.

(4) A new $20 million program of Faculty Awards for summer study, sabbaticals, and special research opportunities. This program would provide 3,000 awards at $5,000 each for summer support to permit currently employed faculty to take advantage of upgrading opportunities; and a $5 million program for experienced faculty for six- to twelve-month periods at salary equivalent to current levels to: (a) permit revitalization, and experience with new research techniques and advanced research discoveries for those who have been isolated from research institutions and centers for six or more years; and (b) provide for intensive development of teaching techniques and materials in problem areas. A total of $20 million authorized in this area will provide awards on a competitive basis to individuals whose institutions certify that the applicant's principal function is undergraduate teaching in a science-related discipline.

Title: A Program to Upgrade and Improve Instructional Programs in Mathematics, Science and Technology at All Levels

Agency:	National Science Foundation
Authorization:	$50 million
Target:	1,000 instructional improvement projects at up to $200,000 each.

Continuing demands are placed on science educators to keep pace with evolving technological innovations. Updated instructional materials are needed to enhance student motivation and to advance the lagging state of science learning. The need for new instructional materials is particularly acute at the undergraduate level for both general students and science and engineering majors.

We propose a new program to improve undergraduate instructional programs and develop school and college materials for mathematics, science and technology education.

Priority areas include:

(1) restructuring subject matter science courses to reflect state-of-the-art technology and the changing needs of undergraduates;

(2) applying teaching and learning research concepts to the development of mathematics, science and technology instructional materials for schools and colleges; and

(3) stimulating collaborative educational institution/industry efforts in the development of improved programs for schools and colleges.

Title: A Program to Upgrade Undergraduate Instructional Equipment and Its Utilization

Agency:	National Science Foundation
Authorization:	$200 million
Target:	Grants to colleges and universities

The outmoded condition of the instructional equipment in the nation's colleges and universities is well-documented. The absence of state-of-the-art equipment and facilities has immediate consequences in the preparation of today's students, and farreaching implications for the nation's ability to remain scientifically and technologically competitive.

We propose a two-part program for:

(1) acquisition and installation of modern instructional equipment for use in teaching and training for teaching; and

(2) sharing science equipment among institutions regionally and between the academic and business sectors.

We further suggest that a balanced program is needed involving all federal agencies that support research and related education programs to make the acquisition of equipment and renovation of laboratories an allowable component of research proposals.

* * * * * * * * * * * * * *

N. B.: Existing laws and recent legislative proposals have attempted to utilize the mechanism of tax incentives to encourage a corporate response to the science education crisis. We regard these proposals as one aspect of the total effort needed to resolve the urgent problems faced by higher education institutions. These proposals are uniquely well-suited to bringing private sector resources into play. Since this paper addresses only the necessary role of the federal government in the direct provision of support, we have omitted references to these tax incentive proposals.

This proposal is submitted on behalf of the following organizations:

American Association of Colleges for Teacher Education
American Association of Community and Junior Colleges
American Association of State Colleges and Universities
American Council on Education
American Educational Research Association
Association of Affiliated College and University Offices
Association of American Colleges
Association of American Universities
Association of Catholic Colleges and Universities
Association of Jesuit Colleges and Universities
Association of Urban Universities
California State University
Council of Graduate Schools in the United States
Council of Independent Colleges
National Association for Equal Opportunity in Higher Education
National Association of College and University Business Officers
National Association of Independent Colleges and Universities
National Association of Schools and Colleges of the United Methodist Church
National Association of State Universities and Land-Grant Colleges
State University of New York

APPENDIX I. ADMINISTRATION PROPOSAL FOR NSF SCIENCE AND MATH EDUCATION PROGRAMS

A PLAN FOR NATIONAL SCIENCE FOUNDATION SUPPORT OF PRECOLLEGE SCIENCE AND MATHEMATICS EDUCATION

SUMMARY

The Administration proposes activities, to be implemented by the National Science Foundation (NSF), that address the declining quality of U.S. precollege science and mathematics education. This decline, which began a decade ago, must be stopped and reversed because the U.S. economic and defense competitivenesss depends heavily on an adequate supply of scientists, engineers and a technically skilled workforce. A strong precollege education in science and mathematics is required to provide the necessary skills.

The plan of activities is designed to meet several conditions. It recognizes that:

1. There are distinct roles for the Federal, state and local governments, and the private sector. The Federal government must assume a leadership and catalytic role, rather than dictate national solutions to local needs.

2. The two principal Federal agencies responsible for science and mathematics education, the National Science Foundation and the Department of Education, have very different statutory authorities and capabilities. The NSF plan described here reflects this difference.

3. The teacher, teaching materials, and techniques are central to the motivation and learning of the students. The planned activities seek to enhance the motivation and competence of the teachers and to facilitate the delivery of knowledge to students.

The proposed plan has two major components: the development of materials and the provision of teacher incentives. These components are discussed in terms of the FY 1983 budget. These activities are planned to continue in FY 1984.

a. Materials Development

The National Science Foundation will support the development of exemplary materials and models for the continuing improvement of teachers. Research and analyses will be conducted and the results continuously fed into the materials development effort so that these materials reflect the best practical experience and ideas, as well as scientific knowledge that can be brought to bear on the processes and content of precollege science and mathematics teaching. The potential of technologies (e.g., computers, television programs) to improve the delivery of materials and the learning processes will be explored. Model programs will be conducted to evaluate and improve the materials developed.

No less than $12 million of the NSF 1983 budget will be devoted to materials development. These materials will be made widely known and available to local educational authorities.

b. Teacher Incentives

Presidential Awards for Teaching Excellence will be given to outstanding science and mathematics teachers. This national recognition of science and mathematics teachers is designed to improve the image and status of mathematics and science teachers. The awards will be administered by NSF in cooperation and with the participation of DoED.

Teacher Honors Workshops will recognize and honor the top quality science and mathematics teachers, provide them with updated knowledge, practical experience or skills, and require that they spread this knowledge to their fellow teachers. These workshops will also be used to provide feedback on, and evaluation of, new teaching materials. Feedback from the workshop participants will be used to analyze science education.

No more than $3 million of the NSF 1983 budget will be used for teacher incentive and recognition.

BACKGROUND

This paper presents the Administration's proposed activities to be implemented by NSF in science and mathematics education. These activities aim to increase the quality of precollege student knowledge in science and mathematics.

School systems throughout the U.S. with strong and dynamic instruction in mathematics and science are vital to the U.S. economy and our Nation's long-term technological leadership. Well educated students are essential to provide a continuing supply of technical personnel needed by a U.S. economy increasingly dependent upon high technology.

The 1970's saw a serious erosion in the quality of U.S. scientific and technological education at all levels. Schools and colleges relaxed requirements for courses in the sciences and mathematics. Academic standards generally deteriorated with emphasis frequently shifted to courses of study lacking a sound disciplinary base. This trend was reflected in the NSF's science education program.

NSF, by its enabling legislation of 1950 and subsequent amendments in 1959, 1965, and 1972, was given major Federal responsibility for scientific research and education in the sciences. The NSF's science education program was substantially strengthened under President Eisenhower in the 1950s, but subsequently underwent a deterioration in the 1970's that paralleled that of the education system in general. The consensus on the importance of NSF's science education program dissipated, leading to disagreement among Congressional committees and within Administrations regarding the role and purpose of the program. This resulted in decreased budgets, loss of program focus, and a proliferation of small, socially directed activities.

The U.S. Office of Education, and later the Department of Education, during this time, was concerned mostly with issues of equity, such as programs for the handicapped, underprivileged, student aid, etc., and capacity building such as construction support. The Department of Education did support educational R&D but this support was also related to equity questions, or was in the nature of national data collection and analysis. Very little effort at the Department of Education was historically directed at the content of science and technology at any level of education.

FEDERAL ROLE

The activities proposed for NSF are consistent with the Administration's view of the proper Federal role in education.

The Administration assumes that:

- An adequate educated population requires strong precollege science and mathematics instruction.
- This requires attention and action by all sectors including state and local governments and industry.
- Local autonomy is a fundamental characteristic of the U.S. educational system. The Federal Government should not interfere with, or dictate to local authorities the design, planning, or operation of education programs. It should act only when a clear responsibility exists.
- In those specific areas where a clear responsibility exists, the Federal Government's role should be to provide the necessary leadership to address a national problem, and also stimulate and catalyze efforts in other sectors.
- Actions by the Federal Government are indicated when:
  - the problem is of a national nature;
  - these actions would provide large public benefits, but by their nature do not present opportunity for economic return to private interests (e.g., data collection and analysis of national data, research and development activities);
  - the actions should but cannot be replicated throughout the states otherwise.
- Federal actions should be targeted at specific, well identified sources of problems. These actions should be aimed at those areas where the benefits of Federal efforts accrue to wide segments of the population.

AGENCY ROLES

Assignment of responsibility for Federal action in the area of science education should be based on:

- statutory authority;
- capability and capacity of the agency based on authority, experience, public support, and support of the involved communities.

NSF and the Department of Education have distinctly different character when examined in light of these two criteria.

National Science Foundation

Statutory Authority

Section 3(a) of the National Science Foundation Act of 1950 states that "the Foundation is authorized and directed:"

- "to initiate and support basic scientific research and programs to strengthen scientific research potential and science education programs at all levels in the mathematical, physical, medical, biological, engineering, social, and other sciences, by making contracts or other arrangements (including grants, loans, and other forms of assistance) to support such scientific and educational activities and to appraise the impact of research upon industrial development and upon the general welfare;"
- "to award, as provided in Section 10, scholarships and graduate fellowships in the mathematical, physical, medical, biological, engineering, social, and other sciences;...."
- "to foster and support the development and use of computer and other scientific methods and technologies, primarily for research and education in the sciences."

Section 3(d) also states that "The Board and Director shall recommend and encourage the pursuit of national policies for the promotion of basic research and education in the sciences." (underlines added)

Capability and Capacity

NSF has some basic characteristics which define the capability and capacity of the agency:

- a relatively small science granting agency staffed by persons with academic/scientific backgrounds; NSF does not conduct in-house research or education programs;
- awards based on competitive peer review, whose primary criterion is the scientific/science educational merit of the proposed ideas and activities;
- strong ties with the academic scientific and engineering community and science teaching profession;
- identification and support of innovative projects which typically are generated through proposals by scientific and technical experts (rather than by NSF).

A clear relationship and compatibility with these characteristics should be a primary consideration in the assignment of Federal responsibility in science and mathematics education to NSF. These strengths should be utilized to greatest advantage. In turn, programs which do not correspond to these characteristics would not only have lesser potential for success, but also weaken the agency's major strengths.

Department of Education

Statutory authority

The enabling legislation of the Department of Education defines a very broad mission, covering responsibilities for all levels of education. However, the legislation prescribes precisely the intended beneficiaries, recipients, funding mechanisms and eligible activities.

Capability and Capacity

Characteristics of the Department of Education which are significant in connection with Federal responsibility for science and mathematics education include:

- a large agency, staffed extensively by persons trained in the fields of education, with history of both funds allocation on uniform, national scale, and educational research at lower education levels;
- concern for equal educational opportunity, with special targeting of issues and groups (e.g., vocational education, bilingual education, disadvantaged groups);
- a variety of functions, ranging from grants-in-aid, to data gathering and dissemination, to national institutional capacity building such as construction of facilities;
- predominant use of formula grants to states and local agencies rather than competitive grants;
- wide contact with state and local educational agencies and colleges of education.

ADMINISTRATION'S EARLY INITIATIVES

Consistent with the definitions of appropriate Federal and agency roles in science and mathematics education, the Administration reviewed the state of the Nation's science and mathematics education and the Federal effort, and:

- Determined the need for Federal leadership in improving the quality of science and mathematics education.

- Recognized the fragmentation of NSF science education programs which prevented achievement of a significant national impact.

- Appointed the Department of Education's National Commission on Excellence in Education (a component of which is directed at science education) to make recommendations "....to the Nation and to the Secretary of Education to promote excellence in public and private schools, colleges, and universities."

- Appointed the National Science Board Commission to study the problems at the precollege level and "....define a national agenda for improving mathematics and science education in this country."

The Administration also has proposed several initiatives as part of a measured plan to reverse the decline in the quality of science and mathematics instruction in the Nation's schools.

- At the university level a new program of support for young science and engineering faculty has been included in the NSF budget. This is aimed at attracting highly qualified, young scientists and engineers to university positions, relieving faculty shortages and assuring high quality university education for future scientists and engineers.

- At the precollege level, Presidentially-directed activities are planned at both the NSF and the Department of Education focused on the supply of science and mathematics teachers and the quality of their teaching:

  -- In 1983, NSF is budgeted at $15 million to conduct two programs aimed at teacher improvement, one updating the materials, skills, and knowledge needed by existing teachers, the other, a program to recognize and reward teachers who have done outstanding work. The budget request for these efforts is increased for 1984.

  -- In 1984, the Department of Education has proposed funding in the amount of $50 million for block grants to the states to increase the number of qualified science and mathematics teachers. The program will provide one year scholarships to persons holding college degrees to enable them to return to school to become qualified to teach science and mathematics.

Independent actions have been taken also by state and local governments, such as pay supplements for science and mathematics teachers. Private industry, scientific and science education groups have made strong public statements of concern and some are increasing their efforts to address those aspects of the problem most closely related to their needs.

PROPOSED PLAN FOR NSF

The Administration's plan for the NSF precollege science and mathematics role in assuring an adequate technically trained workforce, scientific community, and technically functional society is based on these considerations:

- immediate problems and long-term needs for science and mathematics education;
- appropriate Federal and Agency roles;
- primary responsibility at state and local levels;
- need for active and sustained involvement of private sector;
- central role of teachers and teaching materials and techniques in student motivation and learning.

The Administration's Plan for NSF:

- is a measured approach to the clearest and most immediate aspect of the problem --the quality of precollege teaching;
- recognizes the need to undergird scientific and technological training with materials development support;
- includes mechanisms for identification and understanding of problems in precollege science and mathematics teaching.

The plan also coordinates the efforts and utilizes the strengths of the primarily responsible Federal agencies by proper assignment of roles.

National Science Foundation 1983 Precollege Science and Mathematics Activities

1983 Budget
($ in millions)

Materials Development	12
Teacher Incentives	3

Considerable evidence exists that precollege science and mathematics education is inadequate to meet the growing national needs for scientific and technical skills in the workforce.

Numerous studies have pointed to the decline in the quality of science and mathematics education in recent years. These studies have indicated that the precollege level in general, and the quality of precollege teachers and teaching in particular, is the most obvious and immediate source of the problem.

In addition, there is some indication of a decline in performance in science and mathematics of the top quartile of students. This raises questions for America's future health and long-term leadership in technology.

The National Science Board Commission on Precollege Education in Mathematics, Science and Technology, was established to analyze and assess this problem and to make recommendations for its resolution. The NSF science and mathematics education plan for 1983 is based on preliminary Commission reports and findings of national studies and evaluations. It is also consistent with the proper Federal role, and NSF responsibilities and strengths. The plan focuses on the precollege level and is organized around two distinct components:

Development of Materials and Models

- The deteriorating quality of precollege science and mathematics teachers and their instruction is clear. There is a need for exemplary materials and models for the continuing professional development of teachers and the improvement of their instruction. These materials and models should reflect the best practical knowledge, experience and ideas as well as scientific knowledge that can be brought to bear on the processes and content of science and mathematics teaching. They should be based on a thorough understanding of conditions and needs in precollege science education.

Teacher Incentives

- Teaching characterized by low status and salary. There is a pressing need to recognize and nurture the skills of good mathematics and science teachers and to emphasize the significance of their contributions to education and the Nation, as one mechanism of attracting and retaining teachers in these critical skill areas.

Because of the importance and complex nature of precollege science education, care must be taken that NSF activities be of high quality and continuing relevance to national needs. Therefore, continuing input from a broad cross-section of the scientific/science and mathematics education community is essential to:

- advise the Director of NSF and the National Science Board on policies and directions the NSF program should follow;
- identify changing national needs in science and mathematics education;
- review the progress of the program in reaching its long-term goals;
- provide oversight on program procedures;
- provide guidance on revisions to program guidelines.

For these purposes, a Precollege Science and Mathematics Education Advisory Committee will be appointed. The Committee would consist of outstanding individuals recognized as knowledgeable about and experienced in U.S. precollege science and mathematics education, including representatives of local school districts. Prior to the establishment of this group, the NSF will consult broadly with similar types of individuals to review initial program guidelines.

Materials Development ($12 million in FY 1983)

The development of useful materials for teachers and students must be based on a thorough understanding of the conditions and needs of science and mathematics education. For this reason, research and analyses will be initiated to better understand the science and mathematics educational system, and how people teach and learn these subjects most effectively. The research activities by nature are applied and will make use of information on cognitive processes resulting from basic research on this subject (e.g., research sponsored by the Behavioral and Neural Sciences Division of NSF).

A focus here will be on monitoring and evaluating this information, the changes in scientific and technical knowledge, and the relationship of this knowledge to what is taught in the schools. An effort will be made to evaluate and use data collected by organizations with primary data collection responsibilities (e.g., National Center for Educational Statistics and NSF's Science Resources Studies). Evaluation of the impact of NSF science and mathematics education programs will also be included.

New mechanisms and materials will be produced for raising and sustaining the quality of precollege science teaching. Projects will be supported on a nationally competitive basis to:

- create models and demonstrations of innovative training programs focused on scientific and technical content, or new technologies for use in teaching, to provide continuing education for science and mathematics teachers;

- develop materials, audio and visual aids, computer programs, software, and systems for science teachers to use in improving their instruction.

Projects will include design, development and testing of materials, as necessary, operation of prototype programs for teachers, and evaluation of utility and impact of approach. An area of emphasis will be to develop and test applications of the new technologies to precollege science and mathematics education.

The principal products of materials development activities will be better, more effective approaches to teacher training and better tools for teachers and students to use in their classrooms and laboratories. Materials with multiple benefits; e.g., video materials suitable for both public broadcasting as well as classroom use will be included. Although the NSF does not attempt to be strongly prescriptive regarding the nature of projects, anticipated approaches include:

Materials

- better presentations of basic single concepts; e.g., molecular structure, wave motion;
- new techniques to improve student and teacher understanding and productivity, computer simulations of laboratory experiments, modeling, graphing;
- new topics, technology developments, science applications;
- approaches intended not only to provide science instruction, but also to make it more interesting and attractive to younger students.

Demonstrations

- projects structurally designed for individual schools, single school districts, states, regions, or nation-wide;
- national projects based on telecommunications techniques;
- single discipline and multidiscipline projects;
- refresher courses and new topics;
- use of computers and telecommunications in science and mathematics teaching.

The Foundation will require specific products from each development project; e.g., materials, software, descriptive program guides, etc., and where appropriate plans for commercial publication and distribution. Procedures will be developed to assure NSF supported products are available for utilization nationally in local teacher training delivery projects. NSF will consider future mechanisms for making such materials available to local users.

Support criteria will emphasize the participation of a combination of top scientific and teaching talent, and will encourage the appropriate participation of industry. Careful attention will be paid to procedures for assuring the effectiveness of training, such as examinations at the end of programs and the awarding of regular college credit or suitable alternatives recognition of concrete achievement.

It is expected that most proposals will be submitted by colleges and universities, but other institutions with education missions will be equally considered. Appropriate participation and collaboration among practicing teachers, scientists, science educators and officials of state and local education agencies will be a principal consideration for award. In addition, participation and contributions from the private sector, such as the involvement of industrial scientists, will be highly favored in agency evaluation of proposals.

Teacher Incentives ($3 million in FY 1983)

The teacher incentives activities focus on the unique problem of motivating, recognizing and bringing up to date science and mathematics teachers who are among the best the profession has to offer. This complements the materials and teacher training model development activity whose ultimate target population is the precollege science and mathematics teacher profession in general. Teacher incentives include Presidential Awards for Science and Mathematics Teaching Excellence and Teacher Honors Workshops.

The Presidential Awards for Science and Mathematics Teaching Excellence will provide highly visible recognition to approximately 100 outstanding teachers annually (about half in mathematics and half in science). The teachers will be selected nationally with at least one teacher from each state and other jurisdictions such as Puerto Rico and the District of Columbia. They will be presented with a certificate of excellence at an appropriate ceremony. An award of $5,000 will be made to each teacher's school to supplement, and not replace, other resources for use in improving its science or mathematics program, under the direction of the awardee teacher.

The importance of this program was emphasized in a recent radio message by the President when he said, "And we're also beginning a new program, one I intend to participate in myself, to honor some of America's best science and mathematics teachers. They are a true national resource."

The program will be administered by the NSF in coordination with the Department of Education, and with the assistance of a national professional scientific organization. The latter, under contract from NSF, will carry out the identification, nomination, and selection procedures for the awardees, and related necessary activities. The NSF will make the final selections and together with DoED confer the awards. Efforts will be made to obtain the participation and contributions of the private sector such as industrial companies, civic clubs, and local chapters of scientific societies.

The Teacher Honors Workshops activity accomplishes three purposes within the area of precollege science and mathematics teaching development:

-- recognizes and honors top quality teachers;

-- provides these top quality teachers with updating in current science, and mathematics; recent rapid advances in the sciences and technology make it necessary to update the technical knowledge of even the best teachers;

-- obtains for future planning purposes analyses of science education from the unique perspective of the best classroom teachers.

Grants will go to colleges and universities and other institutions with precollege science and mathematics teaching capability to develop, then operate programs of professional improvement for selected precollege teachers. Participation and contributions by industry will be strongly encouraged. Practical experience and demonstrated excellence in the design and delivery of precollege science and mathematics teaching will be emphasized and is strongly encouraged.

Activities consist of:

- identification and selection of science and mathematics teachers of demonstrated high quality and performance; certificates of honor, appropriate publicity, etc. will assure recognition and prestige for the selected;
- development of conference materials;
- workshops that provide specialized training and practical experiences in important areas of science and technology for the participants;
- efforts of participants to collaborate in identification and documentation of current trends, problems, etc. in science education from their perspective to be used by NSF for evaluation and program planning.
- extension of workshop benefits by a requirement that participants carry back to their colleagues materials and information to achieve a wider impact.

Workshops are expected to vary in length depending on the proposed nature of activity and participants. Careful attention will be paid to procedures for assuring the effectiveness of training, such as evaluations at the end of programs and the awarding of regular college credit or suitable alternatives recognition of concrete achievement. The amount requested for 1983 would allow the participation of approximately 700 science and mathematics teachers.

Senator **Hatch**. With that comment we will recess until further notice.

[Whereupon, at 12:10 p.m. the hearing was adjourned.]

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